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SKILLS, KNOWLEDGE, AND ABILITIES UNDERLYING SUCCESS IN USAF PILOT TRAINING

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14. ABSTRACT
The USAF uses two standardized tests, the Air Force Officer Qualifying Test (AFOQT) and the Basic Attributes Test (BAT), as a means of identifying candidates with potential to succeed in pilot training. These instruments have been demonstrated to be predictors of success in the single-track Undergraduate Pilot Training (UPT) program in place since the 1960s. In 1993, the USAF initiated Specialized UPT (SUPT) and introduced a "glass cockpit" training aircraft to the training program for airlift and tanker pilots. SUPT will change with acquisition of a glass cockpit primary trainer and retrofit of the current bomber/fighter trainer with new avionics and instrumentation. Success in this new training environment may depend on attributes not assessed by the BAT or AFOQT. This research was conducted to identify skills, knowledge, and abilities underlying success in current and future SUPT to guide the content of follow-on selection instruments. Task lists for each program and training aircraft were developed, and student and instructor pilots were surveyed on the importance, difficulty, and abilities underlying performance of each task. Results indicated there were no significant differences in ability requirements between the programs and airframes examined.

15. SUBJECT TERMS
Job analysis; Occupational survey; Pilot selection; Pilot training; Specialized Undergraduate Pilot Training; SUPT; Undergraduate Pilot Training; UPT

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PREFACE

We wish to gratefully acknowledge the efforts of the following individuals:

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The research documented in this report was initiated by the Air Force Research Laboratory, Human Effectiveness Directorate, Manpower and Personnel Research Division, under Contract F41624-95-D-5030/0003 with Metrica, Inc, and Work Unit 1123-A1-10, SUPT Analyses. Documentation of this research was delayed due to personnel reassignments and the disestablishment of the Manpower and Personnel Research Division. The final editorial and administrative work necessary to publish this report was accomplished by the Warfighter Training Research Division.

INTRODUCTION

This report describes specific skills, knowledge, and abilities required for successful performance of tasks required of students in United States Air Force (USAF) pilot training. The goal was to produce a scientific description of the job required of pilot training candidates in terms of underlying knowledge, skill, and ability for use in the development of content and balance of future pilot selection instruments.

BACKGROUND

Candidate pilots currently receive their training in the Specialized Undergraduate Pilot Training (SUPT) program. Under this training program candidates are provided mission-oriented flight instruction based on their end assignment. Depending upon this assignment, a candidate will receive training in a tanker-transport track or a fighter-bomber track. Primary flight training for all candidates is provided in the T-37B. Advanced training in the tanker-transport track is accomplished in the T-1A; advanced training in the fighter-bomber track is accomplished in the T-38A. The SUPT program has replaced UPT (used from the mid-1960s through 1997), in which all candidates were provided common training in the T-37B and T-38A regardless of end assignment.

Under current USAF plans, in the year 2005 and beyond, student pilots will be trained in aircraft with sophisticated avionics and navigation systems similar to those in operational aircraft. These plans forecast replacement of the T-37B with the Joint Primary Aircraft Training System (JPATS) and upgrading the T-38A to T-38C to include a major avionics improvement package. In addition, SUPT students to be assigned to fighter aircraft will be provided training similar to the current Introduction to Flight Fundamentals (IFF) course as part of their undergraduate flight training.

Success in SUPT and the forecast training environment may require skills, knowledge, and abilities different from those required in the time-tested UPT program. Candidates for SUPT are currently selected, in part, on the basis of the Basic Attributes Test (BAT), a computer-based battery of psychomotor and cognitive abilities tests, and the Air Force Officer Qualifying Test (AFOQT). The Basic Attributes Test (Carretta, 1990) measures perceptual-motor skills by the 2-hand Coordination (rotary pursuit) Task and the Complex Coordination Task (stick and rudder), spatial orientation in the Mental Rotation Task, multitasking ability by the Time Sharing Task, short-term memory by the Item Recognition Task, and attitude towards risk taking by the Activities Interest Inventory. Carretta and Ree (1995) indicate that the Air Force Officer Qualifying Test (AFOQT) taps the following 16 areas:

- Verbal Analogies
- Arithmetic Reasoning

- Reading Comprehension
- Data Interpretation
- Word Knowledge
- Math Knowledge
- Mechanical Comprehension
- Electrical Maze
- Scale Reading
- Instrument Comprehension
- Block Counting
- Table Reading
- Aviation Information
- Rotated Blocks
- General Science
- Hidden Figures

The AFOQT tends to be more heavily weighted in the area of g (general cognitive ability*)*, mechanical aptitude, spatial orientation, perceptual speed, field dependence/independence, and aviation related knowledge. The BAT, a computer-based test added the dimension of perceptual motor skills analogous to those used by the Air Force fifty years ago. While these selection instruments have been validated as predictors of successful performance in UPT, success in SUPT and the next decade's flying training programs may require some different skills, knowledges and abilities.

With the advancement of technologies in the cockpit, it is hypothesized that the newer aircraft systems will require greater cognitive abilities of their pilots and, perhaps greater fine motor skills and perceptual skills. This report describes analyses of tasks student pilots perform in their present training programs, the content of these courses, and the forecast requirements of the replacement aircraft. Data for the present training aircraft are evaluated in the terms of the anticipated cognitive, noncognitive, and psychomotor demands of the replacement aircraft.

The model for conducting these analyses and evaluations is based on earlier research conducted in support of the Army's future combined Arms Tactical Training (CATT) systems (Koonce, Abbot, & Price, 1994; Koonce & Rogers, 1994; Koonce & Wooten, 1993, 1994). Koonce, et al. developed task analysis questionnaires for specific military systems for the U.S. Army's Simulation, Training, and Instrumentation Command (STRICOM). These questionnaires were designed to assess individuals' perception of the importance of specific tasks, their difficulty to be learned, the need to perform them to maintain proficiency, the opportunity given to practice those tasks, and an assessment of the ability to train those tasks in various environments. The questionnaires, some containing as many as 250 tasks evaluated on eight dimensions, were administered personally to individuals as they would report to a designated location to complete the questionnaire. This approach to obtaining the data provided an opportunity to individually motivate the respondents and to immediately respond to any questions they might have while going through the questionnaire. Those questionnaires served as a model for the development of the survey instruments used in this research.

Task List Development

To assess the tasks, skills, and abilities necessary to train pilots to accomplish their various missions, one must assure that the contents of their individual training systems are appropriate to and reflect the job that must be performed in the operational environment. To know precisely what instruction is needed, the developer must know what tasks and knowledge make up the job, who is to be trained, which of the job tasks they can already perform without further instruction, and the most efficient way of giving them the instruction they need. The initial step in the process requires identification of those training elements required to accomplish the development of pilot candidate into a fully functional Air Force pilot, i.e., a detailed training task list. Such a list was developed by the Air Force during development and implementation of the T-1A system, but similar listings did not exist for other training aircraft. Consequently, it was necessary to develop task lists for other training aircraft.

Using the T-1A Specialized Undergraduate Pilot Training Master Task List as a model, detailed task lists for the other aircraft were prepared. In the case of the T-37 and T-38 aircraft, a combination of syllabi, student guides, and workbooks provided sufficient detail to extract the elements. There was some difficulty in developing the task lists for the T-38C and the JPATS aircraft since they were not yet in the Air Force's inventory. The T-37 tasks were derived from the following sources:

AETC Manual 3-3, Vol.2: Primary Flying, T-37
T.O. IT-37B-1 (Dash 1): Flight Manual T-37B
19AF Syllabus P-4A-B (T-37): T-37 Undergraduate Pilot Training
AETCI 11-201: T-37 Aircrew Operational Procedures
AETC Study Guide/Workbook: Flying Fundamentals
AETC Study Guide/Workbook: T-37 Navigation
AETC Study Guide/Workbook: T-37 Mission Planning
AETC Study Guide/Workbook: T-37 Instruments

The SUPT T-38 aircraft tasks were derived from the following sources:

T.O. 1T-38A-1 (Dash 1): Flight Manual T-38A
19AF Syllabus P-V4A-A (T-38): T-38 Specialized Undergraduate Pilot Training
AETC Student Guide: T-38 Ground Training
AETC Student Guide: T-38 Systems
AETC Student Guide: T-38 Flight Planning
AETC Student Guide: T-38 Systems Analysis/Emergency Action Guide
AETC Study/Guide Workbook: T-38 Instruments

Using the same sources for the SUPT T-38 tasks, supplemented with the Aeronautical Systems

Center report: *T-38 Avionics Upgrade Study - Task Analysis,* by L.T. Wade, III, September 1992, a generalized list of activities, maneuvers, and tasks involved in the pursuit of training in the T-38C aircraft was developed.
The JPATS task list was developed from the *Syllabus of Instruction for Joint Primary Pilot Training (JPPT), AETC/Chief of Naval Air Training, Appendix A: A Hierarchy of Flight Training Objectives in the SP Database,* February, 1994.

The task lists were separated into segments by phase of flight. A careful examination of each flight phase, including all activity routinely accomplished during a given phase (maneuvers, procedures, and checklists) provided an extensive list of tasks. Detailed task listings were screened to simplify and eliminate duplication wherever possible. Subsequently, the task list was reviewed by AETC subject-matter experts (SMEs) for validation.

Questionnaire Development

The tasks were then matched with a compendium of nine basic categories of Knowledge, Skills, and Abilities (KSAs) distilled from listings provided by Fleishman (1966). Pilots were to be asked to rate the extent to which each of the KSAs were needed to satisfactorily perform the individual tasks on a scale of 1 (not at all) to 4 (great extent). Additionally, a rating of the importance of the task ((1) unfamiliar with the task to (5) essential) and the difficulty to learn the task ((1) not familiar with task to (5) very difficult) was solicited from the respondents.

To provide additional evaluation factors, demographic data to include age, grade, pilot rating, recent and total flight time, experience in different types of aircraft, and familiarity with different advanced aircraft systems was collected. Because the T-38C aircraft upgrade contractor had not been selected at the time of the study and there were no SMEs with hands-on experience in the T-38C cockpit, we decided to use T-38 (IFF) instructor pilots to respond to the T-38C questionnaire. It was presumed that these IFF instructor pilots would have had experience, from prior assignments, with some advanced avionics systems similar to those proposed for the T-38C. As a check on their "qualification" to respond to the T-38C type of tasks, we asked the respondents to indicate their degree of familiarity with different advanced aircraft cockpit features such as autopilot, heads-up display (HUD), hands-on throttle and stick (HOTAS) control, flight management system (FMS), global positioning system (GPS), etc.

For each aircraft, the individual tasks were grouped into mission areas based on a logical sequence of activities. Most of the mission areas were common to all aircraft, such as mission planing, takeoff and level off, general airwork, emergency actions, etc., but there were some areas of activity that were unique to specific aircraft because of the nature of their missions.

In their original form, the questionnaires were quite lengthy, requiring some 1800 individual responses for the T-1A aircraft to just under 1400 responses in the case of the T-37 aircraft questionnaire. The feedback from SMEs on the Air Education and Training Command (AETC) staff indicated that the sheer mass of information being requested and the length of time to accomplish the questionnaires would try the patience of respondents, resulting in incomplete or inaccurate responses. To test those concerns, a set of questionnaires on each weapons system was published and administered to a representative cross section of the AETC staff. The reservations of the SMEs were confirmed.

The questionnaires were subsequently revised. In order to reduce the workload on individual respondents, the nine KSAs were divided into three sets as follows:

Form 1	**Form 2**	**Form 3**
Spatial Orientation	Selective Attention	Mechanical Aptitude
Information Recall	Fine Motor Skills	Perceptual Motor Skills
Perceptual Motor Skills	Intelligence	Multi-Tasking

Each of the sets of KSAs were selected so as to minimize the amount of perceived overlap of their domains, which was a complaint when all nine were presented together. Consequently, the target samples were increased by a factor of three in order to obtain the planned number of responses to each of the KSAs. Considering the available pilots at both Randolph and Laughlin Air Force Bases, the increased number of respondents was not considered a problem except for the JPATS aircraft. Since the JPATS aircraft is not yet in the Air Force's inventory, there are only six pilots in the Air Force who have had adequate experience with the JPATS candidate aircraft to provide meaningful responses to our questionnaires. These six individuals were actively involved with the JPATS development and evaluation process. Accordingly, a revision of the JPATS questionnaire into three different forms was inappropriate, so all nine KSAs were retained in a single version of the JPATS questionnaire.

To tie the three different forms of the questionnaires together, the respondents were asked to rate each of 11 Major Mission Events (MME) common to all aircraft in terms of their Importance, Difficulty to Learn, and the extent to which each of the nine KSAs are needed to satisfactorily perform each MME. These Major Mission Events were as follows:

MISSION PLANNING
PATTERNS AND LANDINGS
CONTACT AIRWORK
INSTRUMENT AIRWORK
NAVIGATION
FORMATION
PENETRATION AND APPROACH
EMERGENCY ACTIONS
COMMUNICATIONS AND NAV EQUIPMENT
SYSTEMS KNOWLEDGE
POST FLIGHT ACTIVITY

METHOD

Design. The design was a mixed three-way factorial--one between subjects factor (aircraft) and two repeated measures within subject factors: MMEs and the rating areas of Importance, Difficulty, and the nine KSAs. Several demographic variables were also collected for potential use as covariates if they should account for sufficient variance.

In reviewing the results of this research one must keep in mind the fact that, using SMEs for each of the pilot training programs, biases may be introduced in comparing one training program with another. This could not be overcome because there was not a single group of pilots with familiarity in all of the training programs such that each respondent would rate all of the programs. Consequentially, the pilots were briefed to give their best professional opinion in responding to each of the questions, and the researchers must realize that pilots in one aviation program might have a different response propensity than pilots in another group, a source of uncontrolled experiment-wise error.

Subjects. Pilot training units at Randolph AFB and Laughlin AFB were considered primary sources of subjects because of their proximity to the contractor and they had a considerable number of instructor pilots, pilots, and student pilots, who are familiar with the T-37, T-38, T-1A, and IFF training programs.

The pilots selected to respond to the JPATS questionnaire were pilots who had been participants in the JPATS aircraft flight evaluations. These respondents to the JPATS questionnaires were intimately familiar with the aircraft and its equipment. One must realize that their responses to the questionnaire represent those of a highly select group, a very small sample, and might not be representative of the eventual population of JPATS instructor pilots and student pilots.

Data Collection. Seventy-one copies of the each of the T-37, T-38, and T-1A, 21 copies of the T-38C, and six copies of the JPATS questionnaires were distributed. The lesser number of T-38C and JPATS questionnaires reflects the limited number of pilots with experience in those airplanes. The T-37, T-38 and T-1A aircraft surveys were distributed to a cross section of pilots at Randolph AFB and Laughlin AFB. Lacking an IFF training program at Laughlin AFB, the T-38C questionnaires were distributed only at Randolph AFB. The JPATS questionnaires were sent to two pilots at Randolph AFB, one at Edwards AFB, and one at the Raytheon Beechcraft factory in Wichita, Kansas. Action officers at Randolph and Laughlin AFBs were designated to coordinate the distribution and collection of the questionnaires. The respondents were give a week to complete the questionnaires, furthermore, the respondents were asked to spend only an hour or so at a time working on the questionnaire so as not to be overtasked by the magnitude of the effort.

The distribution of returned questionnaires was as follows:

	Organization	Instructors	Students	Total
T-37 Pilots				
	85th Flying Training Squadron Laughlin AFB	18	20	38
	559th Flying Training Squadron Randolph AFB	18	14	32
	TOTALS	**36**	**34**	**70**
T-38 Pilots				
	87th Flying Training Squadron Laughlin AFB	8	20	28
	560th Flying Training Squadron Randolph AFB	15	11	36
	TOTALS	**23**	**31**	**54**
T-1A Pilots				
	86th Flying Training Squadron Laughlin AFB	15	21	36
	99th Flying Training Squadron Randolph AFB	14	3	17
	TOTALS	**29**	**24**	**53**
T-38C Pilots				
	560th Flying Training Squadron Randolph AFB	9	7	16
JPATS Pilots				
	418th Flight Test Squadron Edwards AFB	1		1
	418th Flight Test Squadron Wichita, Kansas	1		1
	AETC Studies & Analysis Flight Randolph AFB	1		1

RESULTS

Of the 240 questionnaires distributed, 196 were returned. Of those that were returned, 37 were unusable because of clearly inappropriate response patterns or large blocks of no response. Table 1 provides a breakdown for the individual aircraft systems. The T-37 pilots had the best return rate and the smallest proportion of unusable questionnaires.

Table 1. Questionnaire Responses by Aircraft System

Questionnaire	Sent	Received (%)	Unusable (%)	Usable of Sent (%)
T-37	71	70 (98.6%)	10 (14.3%)	60 (84.5%)
T-38	71	54 (76.0%)	11 (20.4%)	43 (60.6%)
T-1A	71	53 (74.6%)	13 (24.5%)	40 (56.3%)
T-38C	21	16 (76.0%)	3 (18.7%)	13 (59.1%)
JPATS	6	3 (50.0%)	0 (00.0%)	3 (50.0%)

Table 2 shows the distribution of questionnaires received by Organization and Pilot Status.

Table 2. Distribution of Questionnaires

T-37 Pilots	Organization	Instructors	Students	Total
	85th Flying Training Squadron (FTS) Laughlin AFB	18	20	38
	559th FTS Randolph AFB	18	14	32
	TOTALS	**36**	**34**	**70**

T-38 Pilots	Organization	Instructors	Students	Total
	87th FTS Laughlin AFB	8	20	28
	560th FTS Randolph AFB	15	11	26
	TOTALS	**23**	**31**	**54**

T-1A Pilots	Organization	Instructors	Students	Total
	86th FTS Laughlin AFB	15	21	36
	99th FTS	14	3	17
	TOTALS	**29**	**24**	**53**

IFF Pilots	Organization	Instructors	Students	Total
	560th FTS	9	7	16

JPATS Pilots	Organization	Pilots		Total
	418th Flight Test Sq., Edwards AFB	1		1
	418th Flight Test Sq., Wichita, KS	1		1

AETC Studies & Analysis Flight Randolph AFB	1	1

Demographics

Table 3 provides some of the demographic data of respondents for each of the aircraft and the three forms of the questionnaires, where applicable.

Table 3. Distribution of the Three Different Forms of the Questionnaires by Officer Rank and Pilot Status for Each Aircraft System

Aircraft		Form 1	Form 2	Form 3	Total
T-37					
	Grade				
	O-1	5	5	4	14
	O-2	1	0	3	4
	O-3	12	13	14	39
	O-4	1	1	1	3
	O-5	2	0	1	3
	Unknown	4	2	1	7
	Rating				
	IP	14	11	14	39
	Pilot	4	3	4	11
	Student	7	7	6	20
	Age	29.5	28.3	29.4	29.1
	(s.d.)	(5.6)	(3.7)	(4.8)	(4.8)
T-38					
	Grade				
	O-1	3	3	2	8
	O-2	0	0	0	0
	O-3	11	4	8	23
	O-4	2	6	2	10
	O-5	1	1	1	3
	Unknown	3	3	3	9
	Rating				
	IP	8	8	6	22
	Pilot	4	2	4	10
	Student	8	7	6	21
	Age	28.3	31.4	30.3	29.9
	(s.d.)	(7.8)	(6.1)	(5.6)	(6.7)

Table 3. Distribution of the Three Different Forms of the Questionnaires by Officer Rank and Pilot Status for Each Aircraft System (Cont'd)

Aircraft		Form 1	Form 2	Form 3	Total
T-1A					
	Grade				
	O-1	5	7	7	19
	O-2	0	0	0	0
	O-3	6	6	6	18
	O-4	3	0	0	3
	O-5	0	0	0	0
	Unknown	1	0	3	4
	Rating				
	IP	9	5	8	22
	Pilot	0	0	0	0
	Student	6	8	7	21
	Age	29.7	27.3	28.2	28.4
	(s.d.)	(4.2)	(3.7)	(3.9)	(4.0)
IFF (T-38C)					
	Grade				
	O-1	0	1	0	1
	O-2	0	0	0	0
	O-3	5	4	4	13
	O-4	0	0	2	2
	O-5	0	0	0	0
	Unknown	0	0	0	0
	Rating				
	IP	3	3	3	9
	Pilot	3	2	2	6
	Student	0	0	0	0
	Age	30.2	24.6	31.8	29.1
	(s.d.)	(1.6)	(11.7)	(2.7)	(7.5)
JPATS					
	Grade				
	O-3				1
	O-4				2
	Rating				
	IP				2
	Age				36.3
	(s.d.)				(0.9)

In terms of the distribution of received questionnaires, there were no statistically significant differences in the number of respondents to the three forms of the questionnaires by grade or by reported pilot positions held.

Screening of the Data

For each aircraft and for each of the scales, internal consistency checks were made for individual outliers, those with "unusual" response patterns, and those who did not respond. Copies of each of the survey instruments are in Appendix C.

Because the tasks were not grouped in the same categories as the MMEs rated at the beginning of the questionnaire, the investigators went into the task lists for each aircraft and identified each task with its appropriate MME. Considering that one's rating of an MME might reflect the aggregate of all the tasks that make up that event, and that the ratings of tasks were on a 4-point ordinal scale, we determined the median value of each individual's responses to the tasks belonging to each of the MMEs.

With regard to the IFF pilots responding to questionnaires for the T-38C aircraft, which were not in inventory at the time of research, the following table shows the degree of familiarity the pilots expressed with the various systems:

Table 4. Pilots' Familiarity with Various Systems

	Very Familiar & Familiar	**Somewhat Familiar**
Global Positioning System (GPS)	67%	87%
Electronic Attitude Indicator	20%	60%
Electronic HSI	7%	60%
Hands-On Throttle and Stick Control (HOTAS)	50%	100%
Aerial Refueling Systems	67%	93%
Autopilot	67%	93%
Collision Warning System	20%	67%
Heads-Up Display (HUD)	60%	100%
Flight Management System	27%	50%

"Very Familiar" indicated that the respondent had been checked out or flown the system, "Familiar" indicated that he had been briefed extensively on the system, and "Somewhat Familiar" meant that the respondent had only read about the system, which could have been from aviation magazines or newspapers to operational manuals. Although a fair proportion of the IFF instructor pilots reported at least being "Somewhat Familiar" with the advanced systems, it was surprising that only 20% or less were "Familiar" or "Very Familiar" with the EHSI, EAI, and TCAS systems and that less than a third were "Familiar" with Flight Management Systems. The researchers' anticipation that these pilots would have had experience in such systems in their previous assignments was only weakly supported. Yet, these were the only pilots available with a likelihood of being appropriate to answer the T-38C questionnaires.

Analysis - IMPORTANCE and DIFFICULTY

Since the MMEs were common to all the aircraft surveyed, an analysis was run on the differences between the aircraft for the IMPORTANCE of the MMEs and their DIFFICULTY to learn. The analyses were performed as a two-factor mixed design ANOVA with repeated measures across MMEs and Aircraft type being the between subjects factor. The measures, IMPORTANCE and DIFFICULTY are independent of each other and thus warrant individual analyses. The 9 KSAs, 11 MMEs were subsequently analyzed as a three-way mixed ANOVA with the between subjects factor being aircraft SYSTEMS.

Statistically, there were no significant differences found between the Aircraft systems over the combined eleven Major Mission Events. For both IMPORTANCE (Appendix B) and for DIFFICULTY (Appendix B-2), there were differences between the MMEs ($p < 0.001$) and significant interactions between Aircraft training systems and MMEs ($p < 0.01$). Figures 1 and 2 are the histograms for the means of the responses for IMPORTANCE and for DIFFICULTY of the 5 Aircraft systems and 11 MMEs.

Overall, the areas of POST FLIGHT ACTIVITY, COMMUNICATIONS/NAVIGATION EQUIPMENT, and CONTACT AIRWORK tended to be rated lower in IMPORTANCE than the other MME (Fig. 1). The significant interaction on IMPORTANCE was attributable to FORMATION where the T-37 and T-1A were rated significantly lower in IMPORTANCE than the T-38 and T-38C systems (Tukey $p < 0.05$). In the area of COMMUNICATIONS/NAV EQUIPMENT, the T-37 and T-1A were rated more IMPORTANT than the JPATS (Tukey $p < 0.05$).

Figure 1. Importance

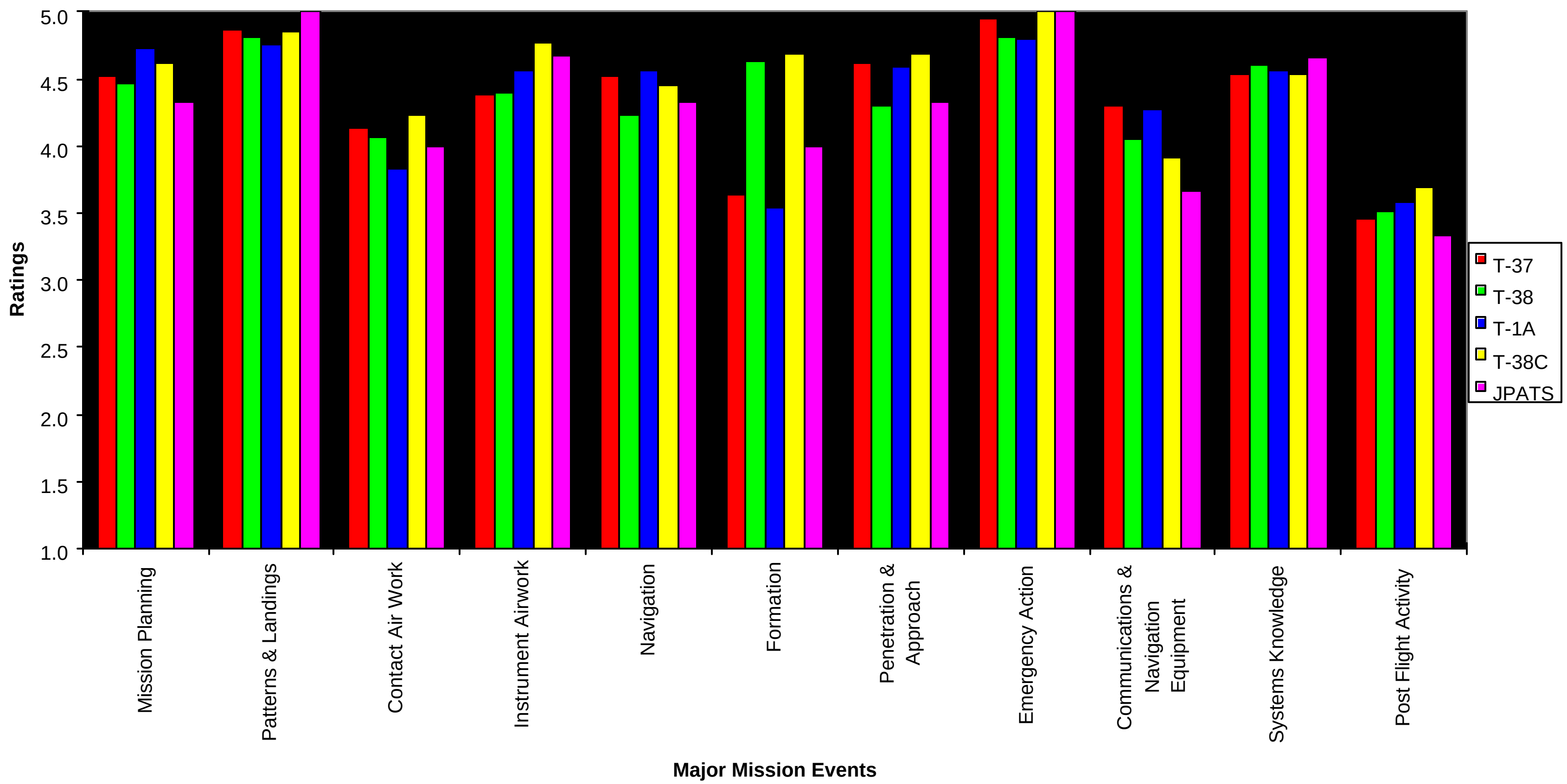
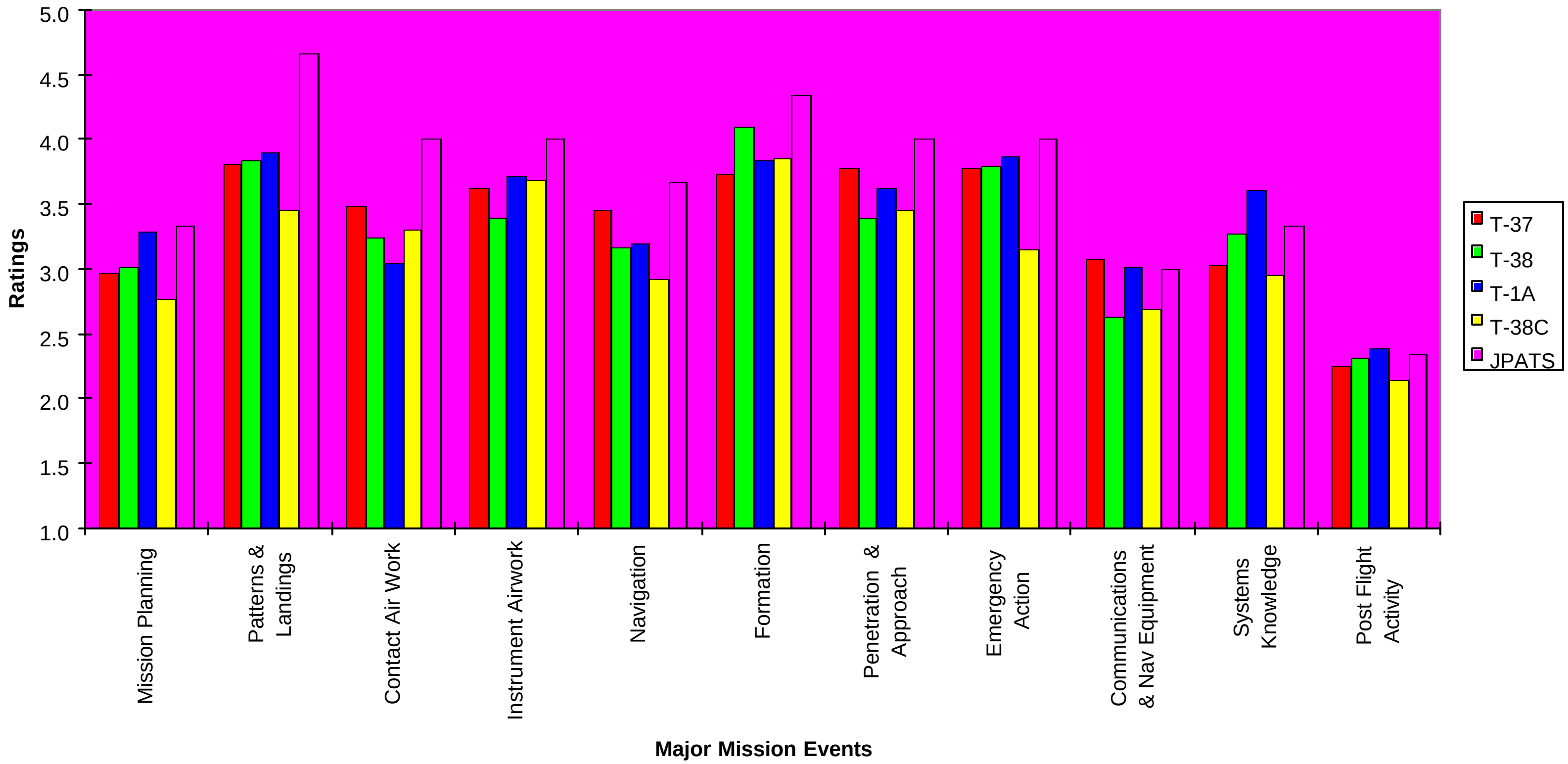


Figure 2. Difficulty



In terms of ***DIFFICULTY*** (Fig. 2), the MMEs of ***Post Flight Activity, Communications/Navigation Equipment, and Mission Planning*** were rated least difficult while the in-flight activities and ***Systems Knowledge*** were rated as more difficult to learn. The JPATS was rated as significantly more difficult to learn in the MMEs of ***Patterns & Landings and Contact Airwork, Instrument Airwork, Formation, and Penetration and Approaches***.

The T-38C system's ***Emergency Actions*** was rated as being less difficult to learn than the four other systems, means of 3.15 and combined mean of 3.60 respectively, and the T-1A ***Systems Knowledge*** was rated as being significantly more ***Difficult*** than the T-38C, means of 3.61 and 2.95 respectively.

Analysis - MAJOR MISSION EVENTS

A three-way mixed ANOVA with repeated measures on two factors (11 MMEs and the 9 KSAs) and the Aircraft Systems being the between subjects factor indicated significant differences between MMEs and between KSAs ($p < 0.001$), between MMEs and Aircraft ($p = 0.017$), and a three-way interaction (KSAs x MMEs x Aircraft) ($p = 0.002$). The aggregate requirement for KSAs differed significantly over the 11 MME areas with ***Post Flight*** and ***Mission Planning*** being the lowest followed closely by ***Systems Knowledge, Communications/Nav Equipment, and Navigation.*** Formation had the highest demand for KSAs with the other five Mission Events closely behind.

Two exploratory three-way ANOVAs were performed on KSAs, MMEs, and Aircraft (T-37 and JPATS or T-38 and T-38C). Looking at the survey data on the T-37 and JPATS, there was no significant difference between aircraft ($p = 0.892$), and the interactions of Aircraft with KSAs, MMEs, or KSAs and MMEs were not significant ($p > 0.80$). As one might expect, there was a significant difference between the KSAs ($p < 0.001$) and between MMEs ($p < 0.001$), and a significant interaction of KSAs with MMEs ($p < 0.001$).

Analysis of the data dealing with the T-38 and T-38C systems revealed similar results: no significant difference between aircraft ($p = 0.758$), no significant Aircraft by KSA interaction ($p = 0.553$), no significant aircraft by MME interaction ($p = 0.278$), and significant main effects of KSAs ($p < 0.001$) and MMEs ($p < 0.001$). There was a significant three-way interaction (Aircraft x KSAs x MMEs) with $F_{(80,4160)} = 1.81$ and $p < 0.001$. Looking at the means of the cells one can see a good bit of variation, but there does not seem to be any particular pattern to explain this three-way interaction.

Subsequent analyses were performed as two-way mixed ANOVAs with aircraft systems being the between subjects factor and the 9 KSAs being the within subjects factor. These analyses were performed on each of the 11 MME areas, Figures 3 and Appendices A-1 through A-10 depict the means of the five aircraft systems over each of the nine KSAs. (See Appendices B-3 through B-13.)

Figure 3. Mission Planning

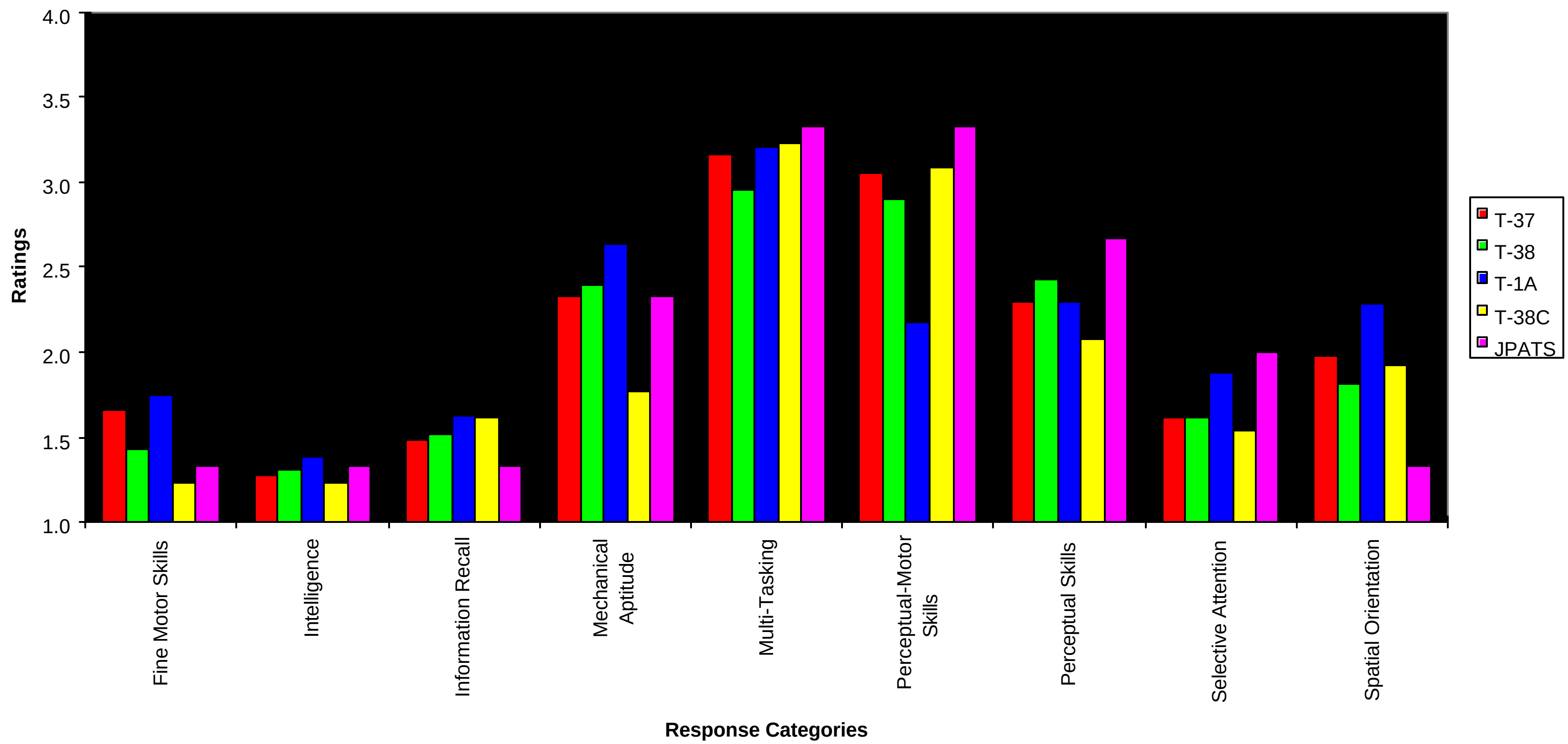


Figure 3 shows the area of ***<u>Mission Planning</u>***, in which there was no significant difference between the aircraft systems, but a very significant difference between the KSAs felt to be needed for the adequate performance of ***Mission Planning*** ($\underline{p} < 0.001$). ***Multi-Tasking*** and ***Perceptual-Motor Skills*** were felt to be more necessary than the other KSAs in the performance of ***Mission Planning***. ***Mechanical Aptitude***, and ***Perceptual Skills*** were the next most important for ***Mission Planning***. Interesting is the fact that ***Intelligence*** and ***Information Recall*** were rated quite low for this MME area.

Traffic ***<u>Patterns And Landings</u>*** (Appendix A-1) showed an overall significant difference between the 11 KSAs ($\underline{p} < 0.001$) with ***A Relatively High Demand For All KSAs Except For Multi-Tasking*** and ***Selective Attention***. Although there was no significant interaction effect, it is interesting to note that the T-37 system was rated as having a much higher need for ***Selective Attention*** in the performance of ***Patterns and Landings*** than the other systems.

The MME area of ***<u>Contact Airwork</u>*** (Appendix A-2) showed a significant difference ($\underline{p} < 0.001$) between the KSAs required to adequately perform this mission areas, with ***Information Recall***, ***Fine Motor Skills***, and ***Spatial Orientation*** being required most and ***Multi-Tasking*** and ***Selective Attention*** being needed the least. Again, although there was no statistically significant interaction effect, the histogram indicates that JPATS as being more demanding of ***Perceptual-Motor Skills*** and ***Perceptual Skills*** and less demanding of ***Fine Motor Skills*** than the other aircraft.

<u>Instrument Airwork</u> (Appendix A-3) was uniformly demanding of all of the KSAs except ***Selective Attention*** ($\underline{p} < 0.001$) for all of the aircraft systems, and there was no significant interaction effect.

For ***<u>Navigation</u>*** there was significant difference between the KSAs required with ***Information Recall*** required the most and ***Selective Attention*** the least ($\underline{p} < 0.001$) (See Appendix A-4). The JPATS respondents indicated a greater need ***For Intelligence, Perceptual-Motor Skill, Perceptual Skills***, and ***Selective Attention*** while the T-38C required the least of these four areas as well as ***Multi-Tasking***.

Like many of the previous MME areas, ***<u>Formation</u>*** (Appendix A-5) showed a significant difference between KSAs ($\underline{p} < 0.001$), but no significant difference between AIRCRAFT systems and no significant interaction between AIRCRAFT and KSAs. ***Selective Attention, Perceptual-Motor Skills,*** and ***Multi-Tasking*** were least important for ***Formation***, and the others were all equally important. There was a nonsignificant tendency for the JPATS system to be rated higher on need for ***Information Recall, Mechanical Aptitude, Perceptual Skills***, and ***Selective Attention***.

The two-way ANOVA on ***Penetration & Approach*** showed a significant difference in MMEs ($p < 0.001$) and no significant difference in Aircraft systems and no significant interaction. Appendix A-6 is the histogram for this data. It clearly indicates that ***Selective Attention*** was significantly lower in demand for the performance of this mission event ($p < 0.01$). Although ***Multi-Tasking*** was also lower in demand than the other seven KSAs, it was not statistically significantly lower in the *post hoc* test.

The analysis of ***Emergency Actions*** indicated a significant difference between MMEs ($p < 0.001$) and no significant difference between Aircraft systems and no significant interaction. Appendix A-7 depicts the means of the aircraft over the nine KSAs. It is interesting to note that JPATS, while relatively strong in demand for KSAs in other MMEs, is relatively low in need for KSAs in ***Emergency Actions***.

Communications & Nav Equipment had a significant ($p < 0.001$) difference between the KSAs with the combined ***Fine Motor Skills, Intelligence***, and ***Information Recall*** being less in demand than the other six KSAs (Appendix A-8). Again, there were no significant differences found between Aircraft systems and no significant interaction effect.

Under ***Systems Knowledge*** (Appendix A-9) there was a significant difference between KSAs ($p < 0.001$) and a significant difference in Aircraft systems ($p < 0.022$) with no significant interaction. Looking at the Figure, one can see that ***Multi-Tasking*** and ***Perceptual-Motor Skills*** were significantly higher than the other KSAs ($p < 0.02$). The T-1A was in greater demand of KSAs for ***Systems Knowledge*** than T-38C and JPATS ($p < 0.05$).

As one might expect, the ***Post-Flight Activity*** (Appendix A-10) required the least of the KSAs, compared to the other MME areas. Similar to ***Mission Planning*** and ***Systems Knowledge***, there was a significant difference between KSAs with ***Multi-Tasking*** and ***Perceptual-Motor Skills*** being significantly higher than the other KSAs ($p < 0.02$).

Analysis - REMOVAL OF STUDENT PILOTS

Thirty-seven percent of the respondents to the questionnaires were student pilots. Because there may be grounds to question the student pilots' ability to respond as "subject matter experts" on a given training program, a subsequent analysis was conducted using only the pilots and instructor pilots, with the omission of the student pilots (N=55) from the database. See Appendices A-11 through A-14 for histograms of the data in which the removal of the student pilots had a significant effect on the results of the analyses.

In terms of ***Importance***, with the students removed (Appendix A-11), the results were overall quite similar to the original analysis (Fig. 1). But, there were some changes in the comparison of cells in that the T-1A was rated significantly lower than the other four aircraft for the mission event ***Contact Airwork*** ($p < 0.01$), and the T-37 came up in ***Importance*** for the mission event ***Formation*** leaving the T-1A significantly lower than the other four aircraft. The T-38 and T-38C still has higher ***Importance*** ratings on ***Formation*** than the other aircraft systems ($p < 0.05$). The differences previously observed between the aircraft systems for ***Communications/Navigation Equipment*** remained virtually the same with the students removed. (See Appendix B-14.)

The profiles of the aircraft systems for ***Difficulty*** to learn over the 11 MMEs are the same without the students in the database. Appendix A-12, developed from Appendix B-15, shows little difference from the earlier analysis (See Fig. 2). One exception, is that the ***Formation*** ratings for the T-37 and T-38 increased in ***Difficulty*** with respect to the other aircraft when the students were removed. Essentially, this indicates that the Instructor Pilots thought that ***Formation*** was more difficult to learn than the Students perceived it to be.

The removal of the Student Pilots from the database had no significant effect on the results of the ANOVAs for ***Mission Planning, Patterns and Landings, Contact Airwork, Instrument Airwork, Navigation, Formation, Emergency Actions, Communications/ Navigation Equipment, and Post-Flight Activity.***

But, for ***Penetration & Approach (Appendix B-16)*** the removal of the students resulted in a finding of a significant difference between Aircraft systems ($p < 0.05$). Comparing Figures 16 with 9, one can see that the T-1A requirement for ***Selective Attention*** decreased quite a bit when the students were removed, and for ***Mechanical Aptitude*** the T-37 and T-1A increased while the T-38 decreased. The significant difference between aircraft was due largely to the overall increase of the T-37 and decrease of the T-38 for KSAs.

The ANOVA on ***Systems Knowledge*** with the students removed show no significant difference between Aircraft systems $p < 0.072$ compared to $p < 0.022$ with the students included Appendix A-14. As in the ANOVA that included the students, the marginal means between Aircraft systems (Appendix B-17) still had the T-1A as most demanding of the KSAs for ***Systems Knowledge,*** with the T-38C and JPATS as requiring the least of the KSAs.

Analysis - KSAs

Looking at the three-way ANOVA from another aspect, we have provided histograms for each of the 9 KSAs showing the 5 Aircraft systems by the 11 MME areas (Appendices A-15 to A-23). For each of these dependent variables there were significant differences between the MMEs ($p < 0.001$), and only four of the analyses indicated significant interaction effects: ***Fine Motor Skills, Mechanical Aptitude, Multi-Tasking, Perceptual-Motor Skills, and Perceptual Skills***. The actual mean ratings are given in Appendices B-18 through B-26 for the five aircraft. Note that the aircraft in the figures are grouped with the standard UPT T-37/T-38 sequence first, followed by the T-1A, an advanced SUPT aircraft, followed by the T-38C and followed by and JPATS.

Fine Motor Skills were in least demand during ***Mission Planning, Communications/Nav Equipment, Systems Knowledge, and Post-Flight Activity***. The interaction effect was significant ($p = 0.036$). The JPATS was significantly lower in demand for ***Fine Motor Skills*** during ***Contact Airwork***, and the JPATS and T-38C were significantly lower in the area of ***Systems Knowledge***. Overall, there were no systematic differences between Aircraft over the 11 MME areas (See Appendix A-15).

Information Recall showed a profile (Appendix A-16) similar to most of the other skills and abilities, in that it was in low demand for ***Mission Planning, Communications/Nav Equipment, Systems Knowledge***, and ***Post-Flight Activity***. The JPATS respondents indicated a somewhat greater demand for information recall during the Formation mission areas, but this was not significant.

The demand for Intelligence (Appendix A-17) was relatively low for the MME areas of ***Mission Planning, Systems Knowledge, and Post-Flight Activity***. For the areas of ***Navigation, Formation***, and ***Communication/Navigation Equipment,*** the JPATS tended to be rated higher in their demands on ***Intelligence*** than the T-38C.

Mechanical Aptitude, a person's ability for using and/or understanding mechanisms such as tools and machines, was higher in demand for the In-Flight MME areas than the others (Appendix A-18). The interaction term of the ANOVA was significant ($p = 0.039$), but *post hoc* analyses (Scheffe) did not reveal any significant pair-wise comparisons.

For ***Multi-Tasking***, the ability to effectively prioritize workload and perform simultaneous efforts under demanding situations, differed significantly between MME areas and had a significant ($p < 0.001$) interaction between Aircraft and MMEs (Appendix A-19). It is interesting to note that while Emergency Actions was rated the greatest in demand of ***Multi-Tasking*** ability***, Mission Planning, Instrument Airwork, and Systems Knowledge*** were rated the next highest. Looking at the plot of the data, it is difficult to discern any notable changes between aircraft as a function of MME that would have resulted in the significant interaction.

Perceptual Skills (Appendix A-20) also showed little differences between aircraft, except for the JPATS being a bit higher during ***Mission Planning, Contact Airwork, Navigation, and Formation*** flight, a significant interaction ($p = 0.016$). Of course, ***Systems Knowledge*** and ***Post-Flight Activity*** had low demand for Perceptual Skills as they were defined: "The relative proficiency in detecting and interpreting information received from sensory input; visual, aural, tactile, etc."

The ability to conduct any activity which involves a combination of the individual's sensory, cognitive, and motor functions, ***Perceptual-Motor Skills*** (Appendix A-21) was somewhat higher in demand in ***Navigation, Instrument*** flight, and ***Emergency Actions***. An unusual result is that one of the greatest demands for PERCEPTUAL-MOTOR SKILLS was in the

MME area of ***Systems Knowledge***. There was a significant interaction effect ($\underline{p}$ = 0.049) that can be seen in the JPATS relative to the other aircraft, being higher in six areas and low in three other areas.

With regards to ***<u>Selective Attention</u>*** (Appendix A-22), the ability to consciously or willfully focus on a restricted set of desired inputs, to the exclusion of the remaining concurrently impinging sets (focused attention), shows ***Emergency Actions*** as the most demanding while ***Mission Planning*** and ***Post-Flight Activity*** are the least. The JPATS aircraft is relatively high on this factor for ***Patterns & Landings, Contact Airwork, Instrument Airwork, Navigation, Formation***, and ***Penetration/Approaches***. The T-38C aircraft was rated lower in all Mission Event Areas except for ***Systems Knowledge***.

The overall aircraft ratings of demand for ***<u>Spatial Orientation</u>*** were somewhat lower than for other abilities. Spatial Orientation (Appendix A-23) was not perceived as being very necessary for ***Mission Planning, Systems Knowledge***, a***nd Post-Flight Activity***, but it was relatively high for the flying activities of ***Patterns & Landings, Contact Airwork, Instrument Airwork, Formation, Penetration & Approaches, and Emergency Actions***.

DISCUSSION

In the task analyses of various systems by Koonce, *et al*., the respondents reported to a specific location during specified blocks of time for the purpose of completing the questionnaires. The researchers were present to hand out the forms, brief the respondents regarding the purpose and importance of the project, and were available to answer any questions the respondents might have. Also, the researchers could scan the questionnaires for flawed responses before accepting them from respondents. The procedure of the current study resulted in 18.3% of questionnaires not being returned, and a further loss of 18.8% of those returned due to improper responding.

Looking at each of the KSAs individually, there was no difference between the aircraft, but the general trend was for the T-37, T-1A, and JPATS to be higher than the T-38 and T-38C. It is difficult to ascertain how much of the differences between aircraft systems were due to the differences between subjects or the actual differences between the aircraft. Until we have experts rate more than one aircraft or have them all rate a common aircraft as an anchor point, this potential for bias in ratings cannot be controlled, statistically or by experimental design. Additionally, the limited number of subjects answering the JPATS and T-38C questionnaires resulted in a large difference in sample sizes between aircraft, another source of analysis error.

Even when directly compared in three-way ANOVAs, no significant difference could be found between the data for the T-37 and the JPATS, and the lack of significant difference between these aircraft systems did not change as a function of interaction with the KSAs or the MMEs. Similarly, no significant interaction could be found when directly comparing the T-38 and T-38C, and their interactions with KSAs and MMEs showed no significant effects. There was a significant, but unexplainable, three-way interaction of T-38/T-38C x KSAs x MMEs.

With regard to the KSAs, the T-37 and T-1A aircraft systems tended to require a greater amount of each of the KSAs than the T-38 or T-38C. The JPATS was quite similar to the T-37 and T-1A on five of the KSAs and similar to the T-38 and T-38C on three others. But, the advancements in the newer technology cockpits over the traditional T-37/T-38 systems seem to have little effect upon the perceived KSAs required to perform the various tasks of the Major Mission Event areas.

The T-1A, which is already operational and technologically more advanced than the T-37 or T-38 aircraft, showed no significant difference from them in terms of need for KSAs, and surprisingly, it was most similar to the T-37.

RECOMMENDATIONS

1. Additional research should be conducted wherein the respondents are individuals who have been current in one aircraft and have been up-graded to the "follow-on" aircraft, such as T-37 to JPATS, or T-38/IFF to T-38C, so that they can respond to the tasks of both aircraft systems; a before/after comparison design. These individuals would be more apt to rate the tasks and MME areas on the same scale, a within subjects design versus a between subjects design. Then, comparisons could be made between two aircraft systems rated by the same pilots.

2. Subsequent task analyses of this sort should be given to the respondents personally with an individual briefing and a time and place for them to complete the questionnaires which would provide the respondents with a greater sense of value for which their responses would be held.

3. The value of using student pilots as subject-matter experts is questionable unless they are in sufficient quantity to be analyzed separately and in comparison to the instructor pilots.

4. Further analysis should be conducted with the database of this experiment and/or subsequent studies to see which tasks contribute most to the ratings of the respective MME areas. In doing that, one could go back and calculate most highly with the ratings of the MME and which do not relate to the ratings of the MME. Or, one could perform a factor analysis to determine the factor loadings for the individual tasks as they relate to their particular major MMEs, and comparisons could be made between the aircraft systems to see if they differ in the relative importance of the various tasks in accounting for the ratings of the various MMEs.

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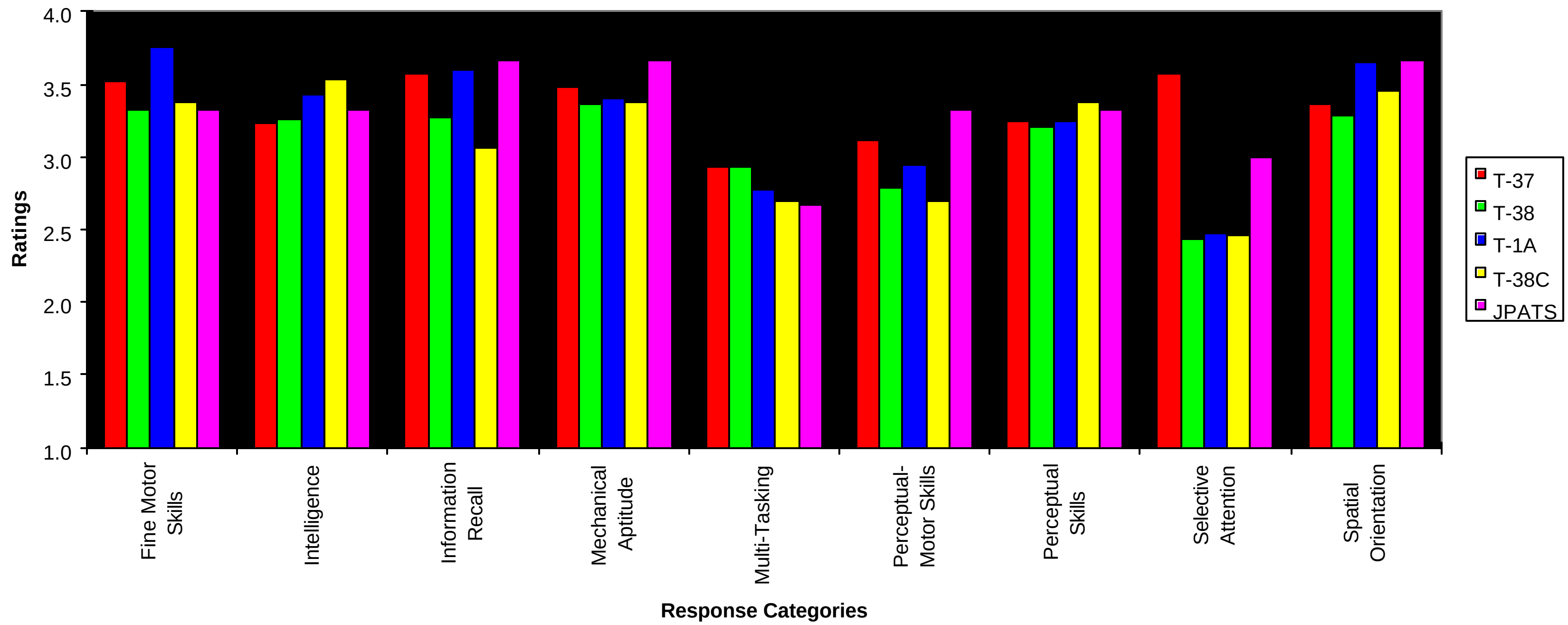
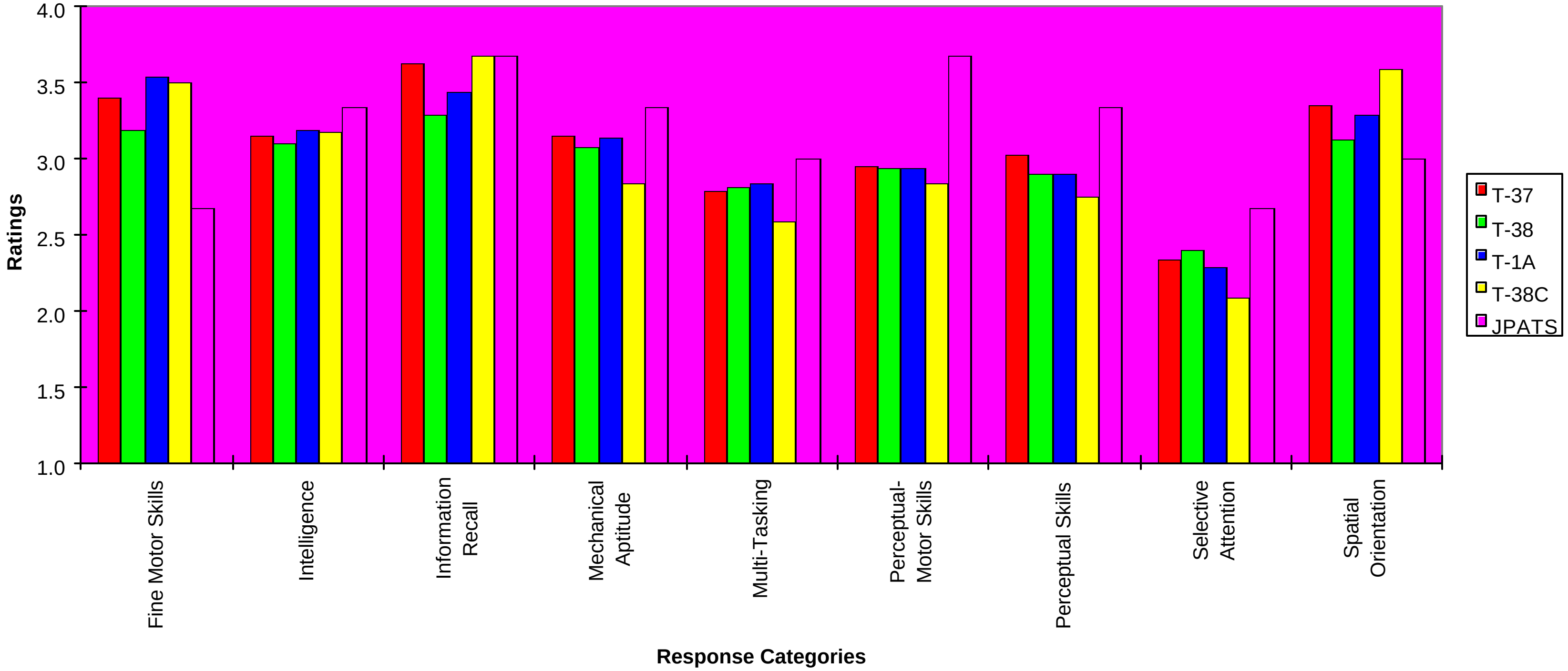
APPENDIX A

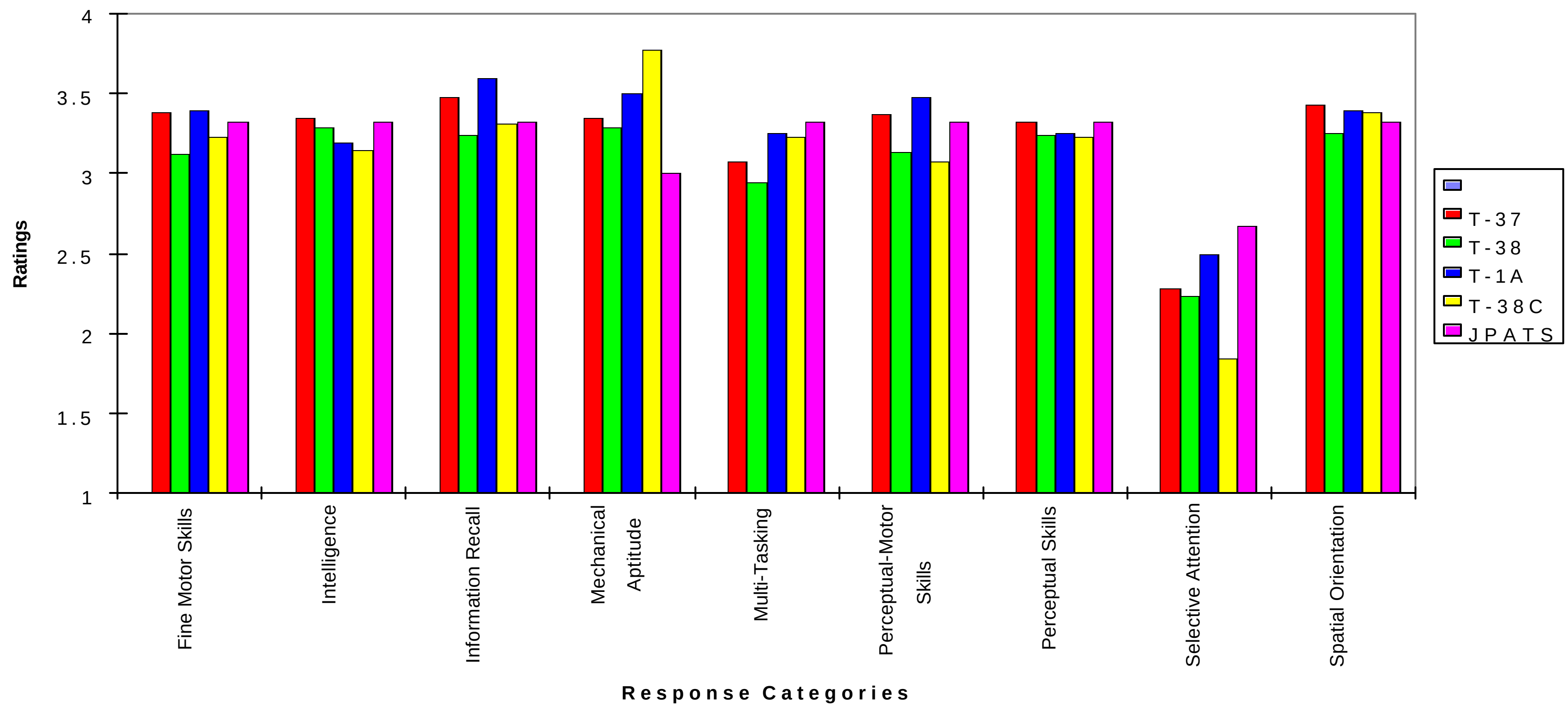
Appendix A-1. Patterns and Landings



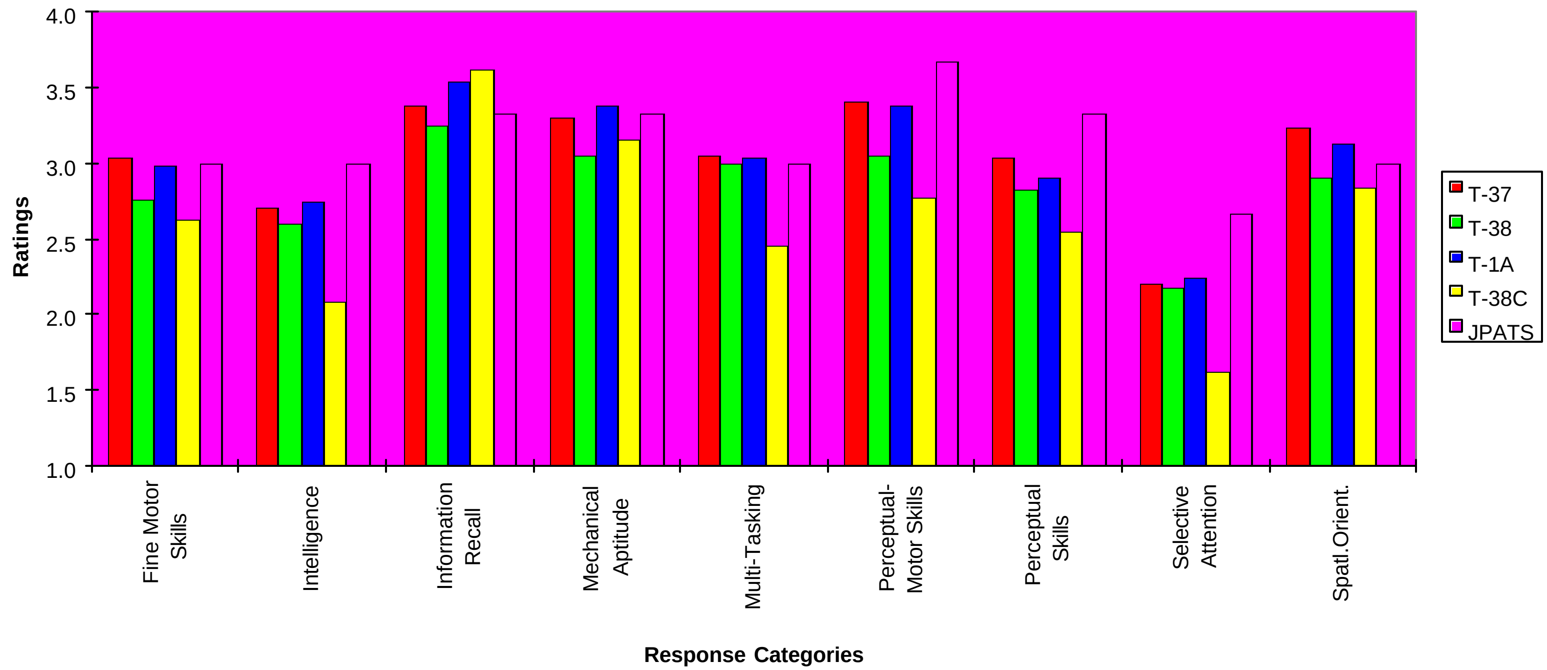
Appendix A-2. Contact Airwork



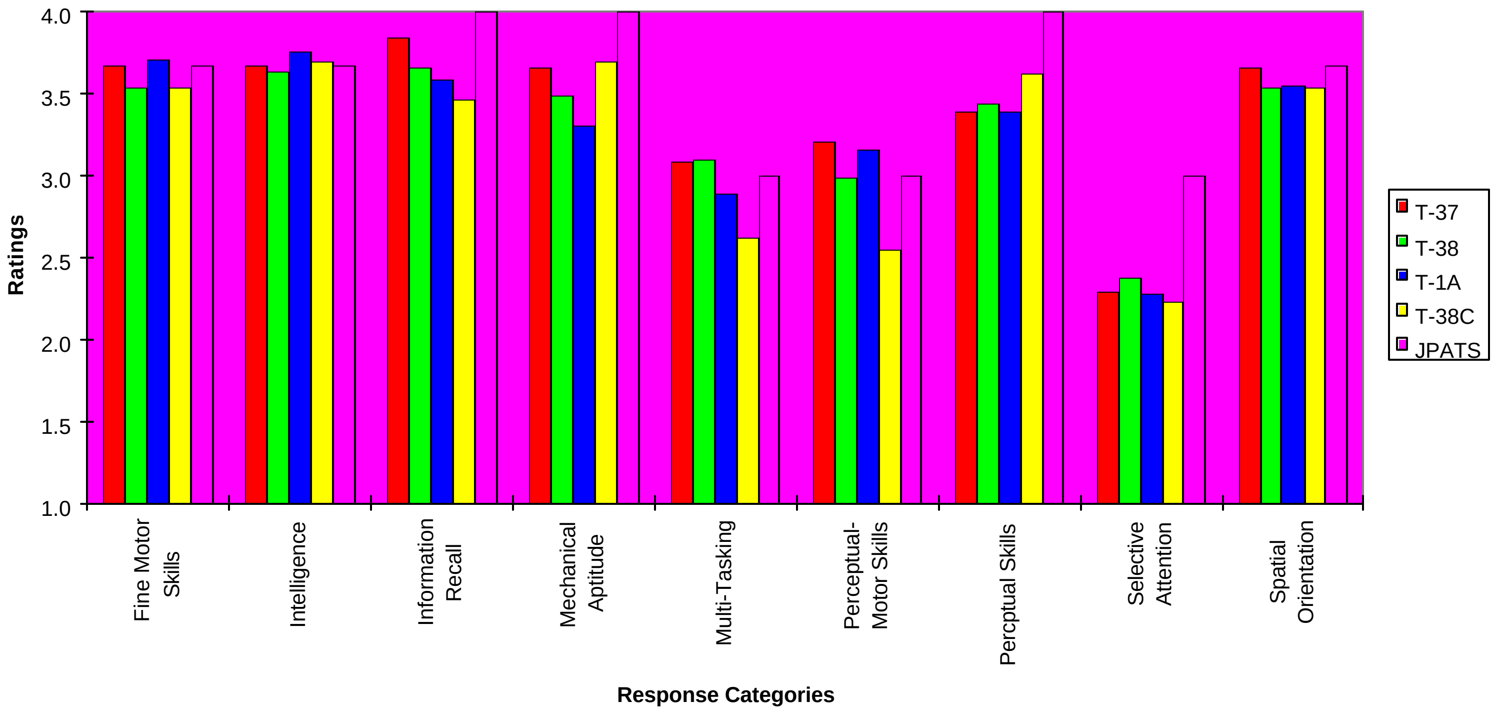
Appendix A-3. Instrument Airwork



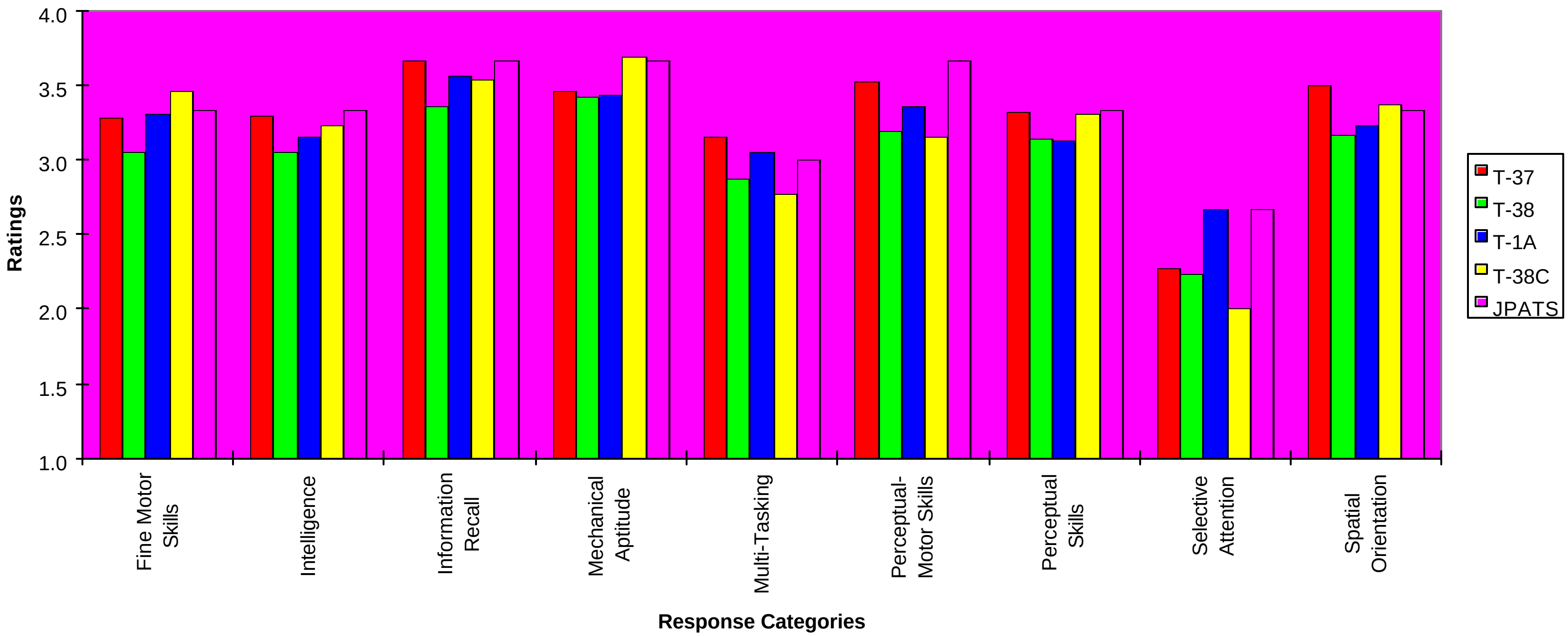
Appendix A-4. Navigation



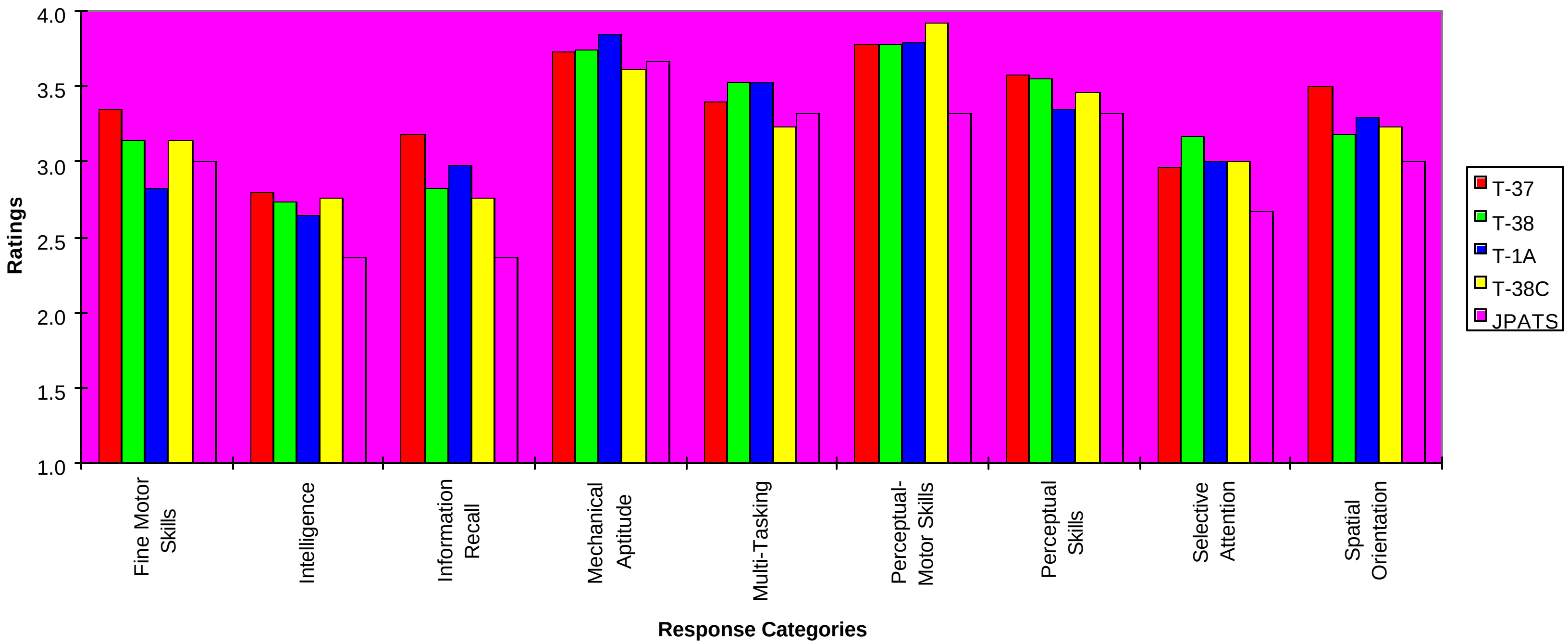
Appendix A-5. Formation



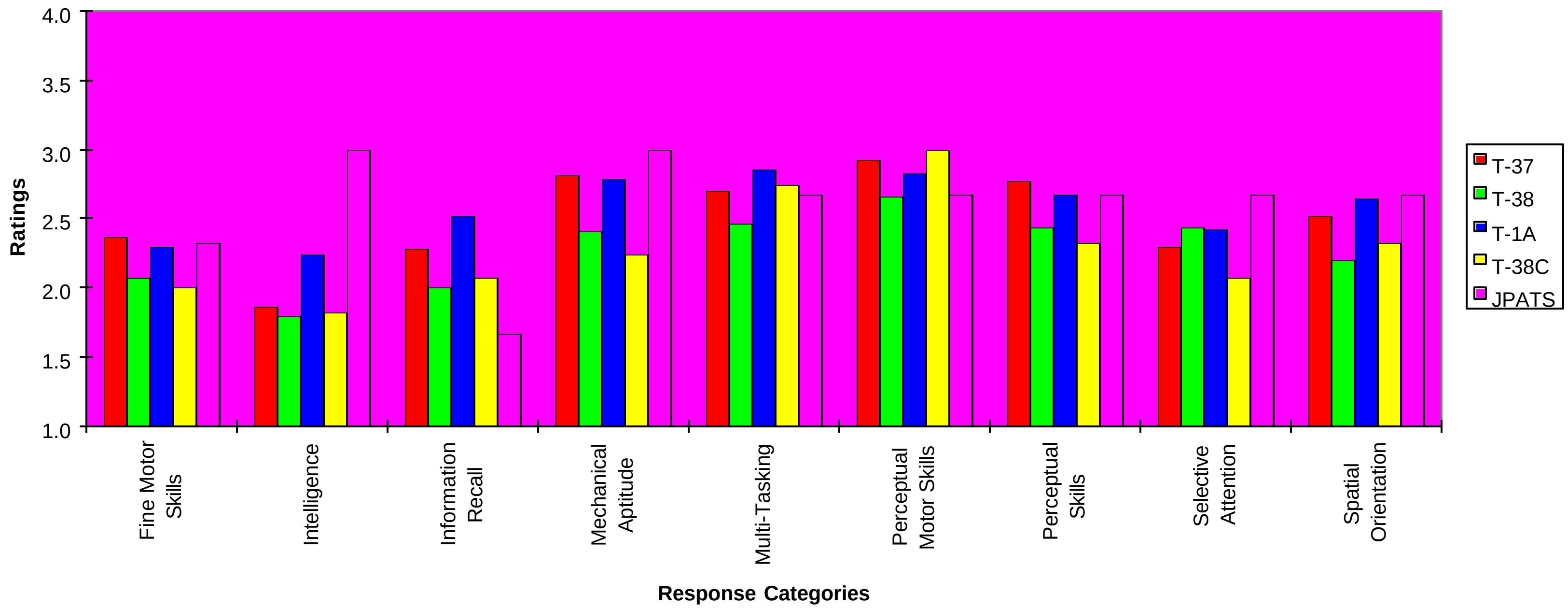
Appendix A-6. Penetration and Approach



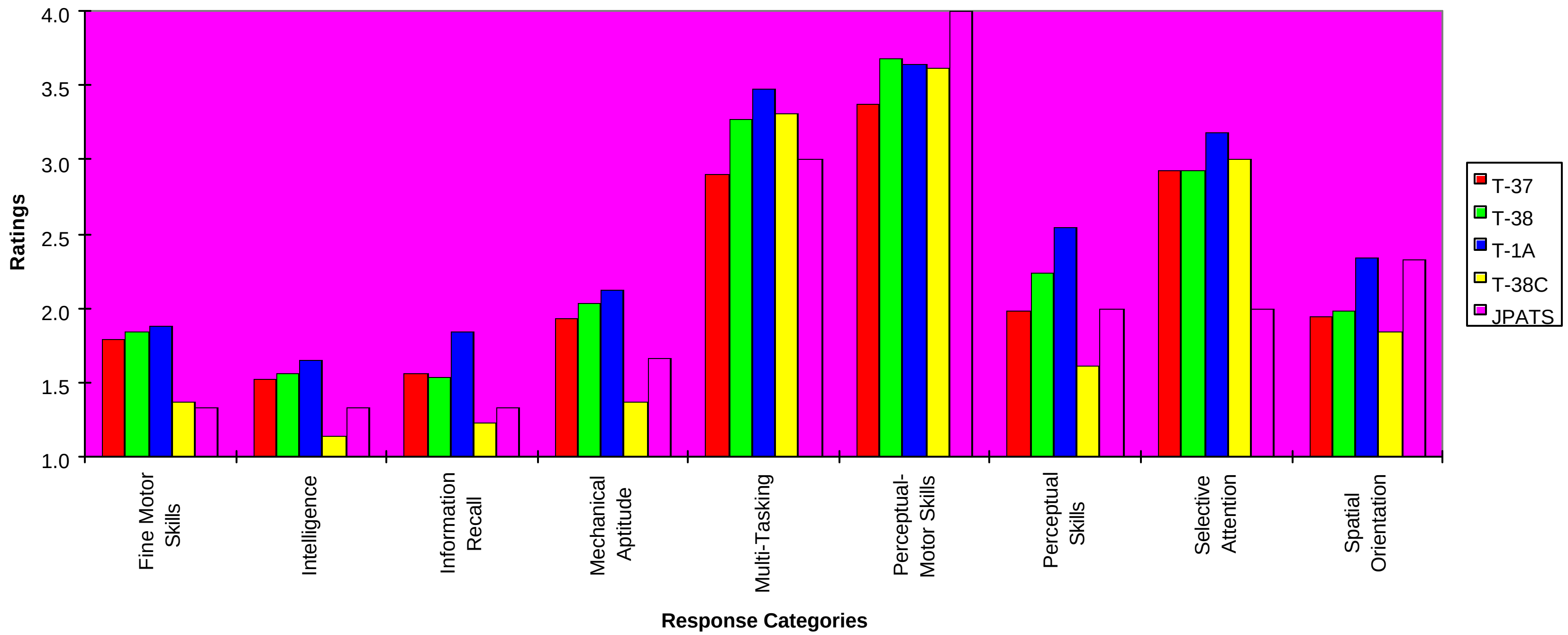
Appendix A-7. Emergency Action



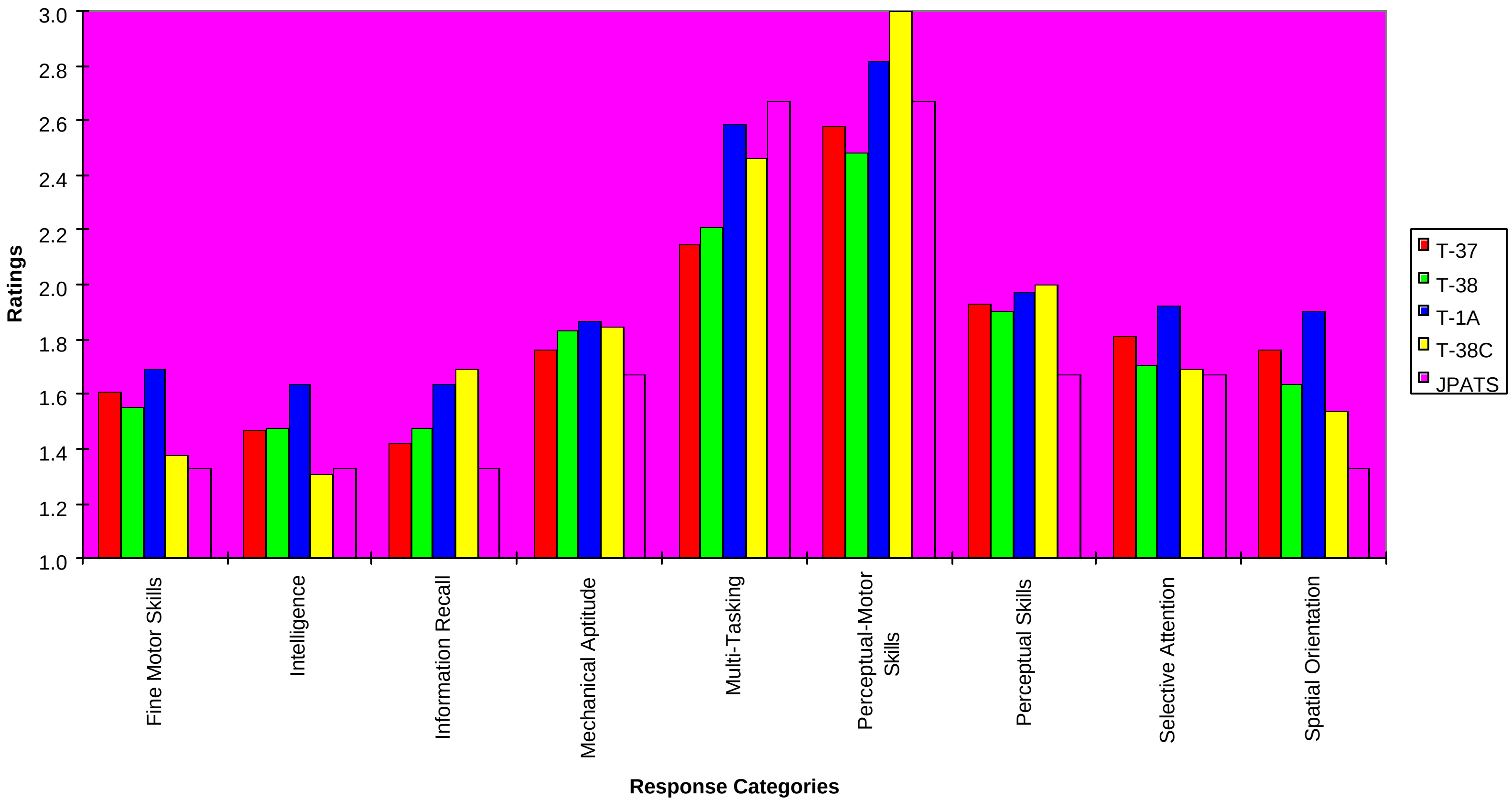
Appendix A-8. Communications and Navigation Equipment



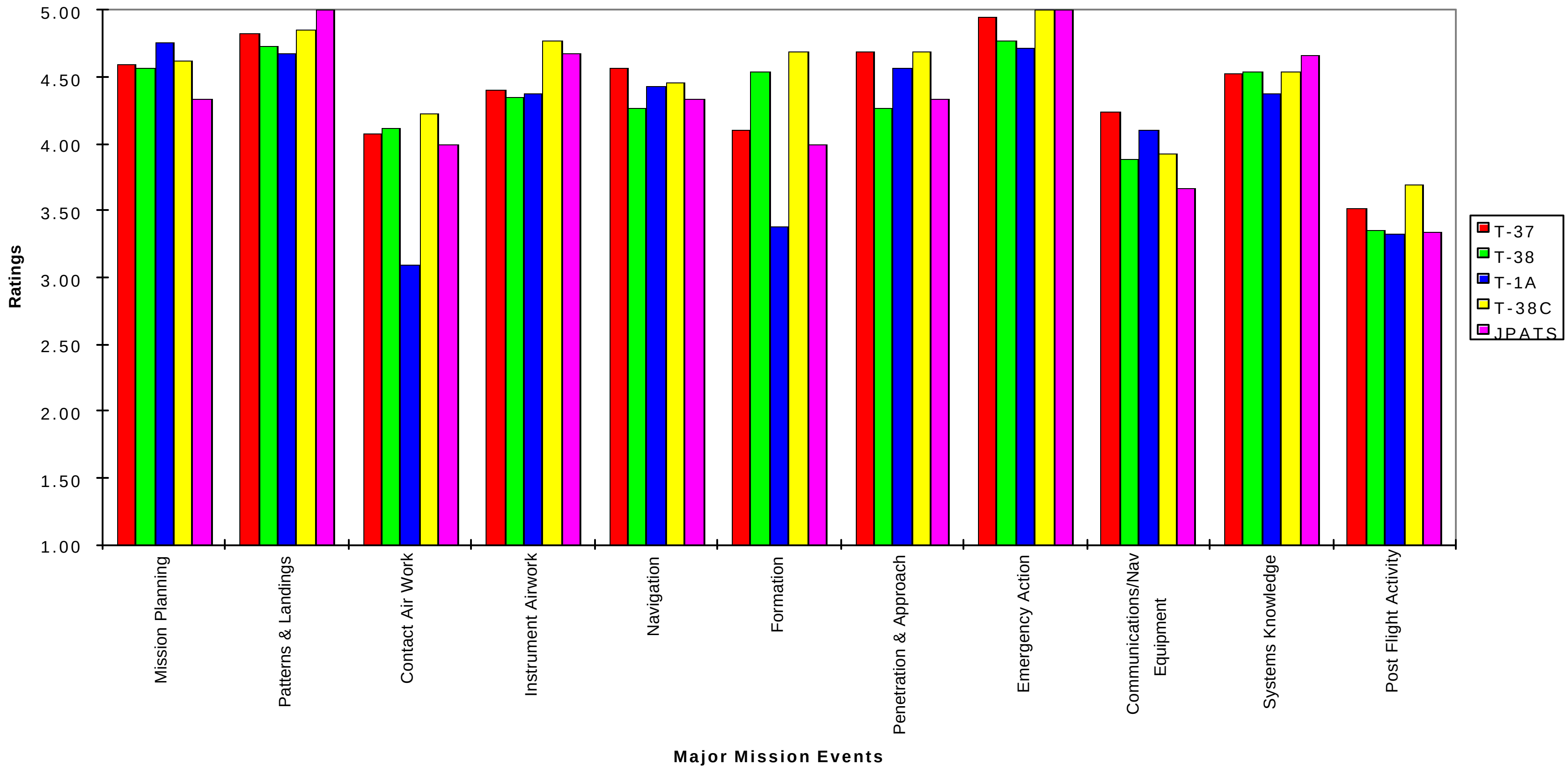
Appendix A-9. Systems Knowledge



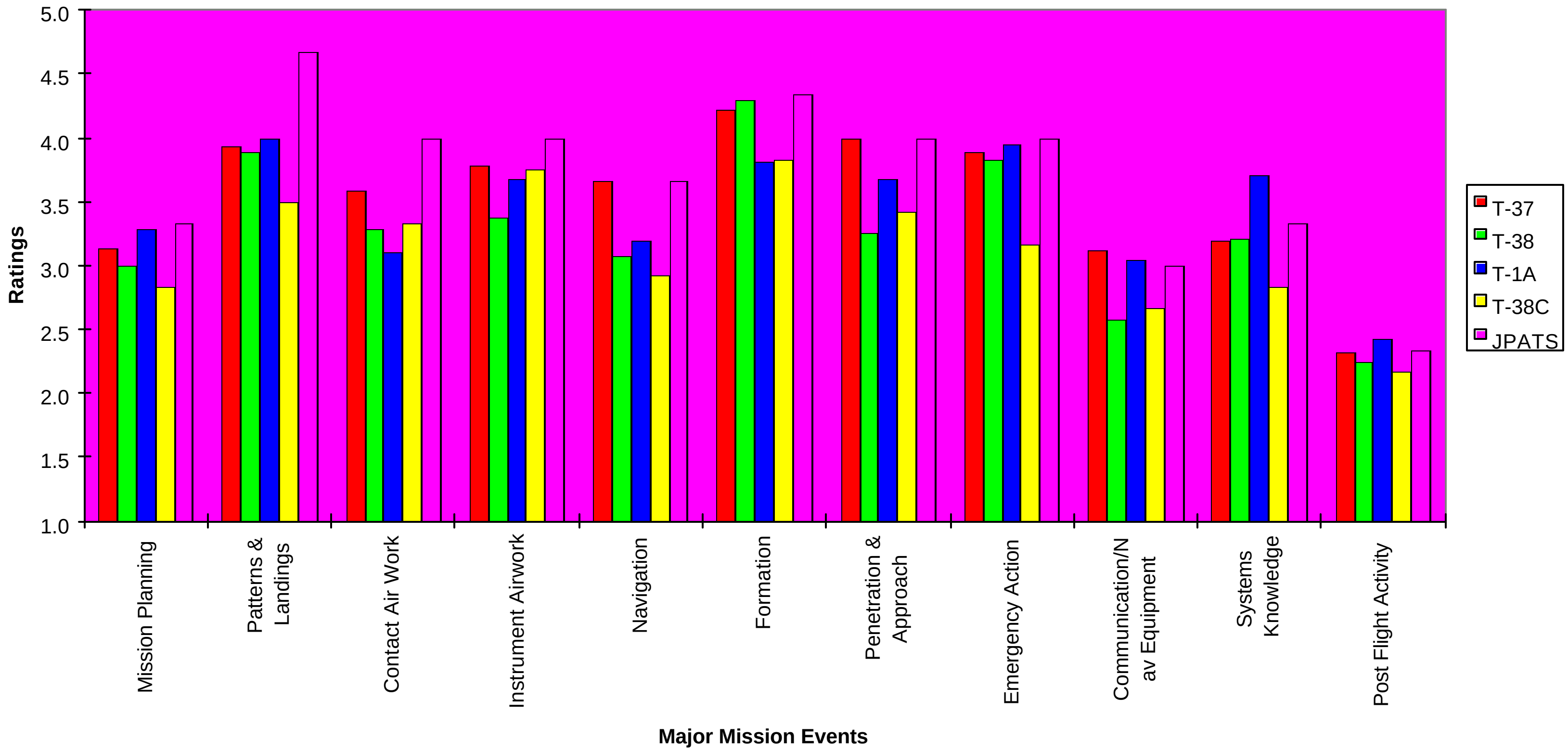
Appendix A-10. Post Flight Activity



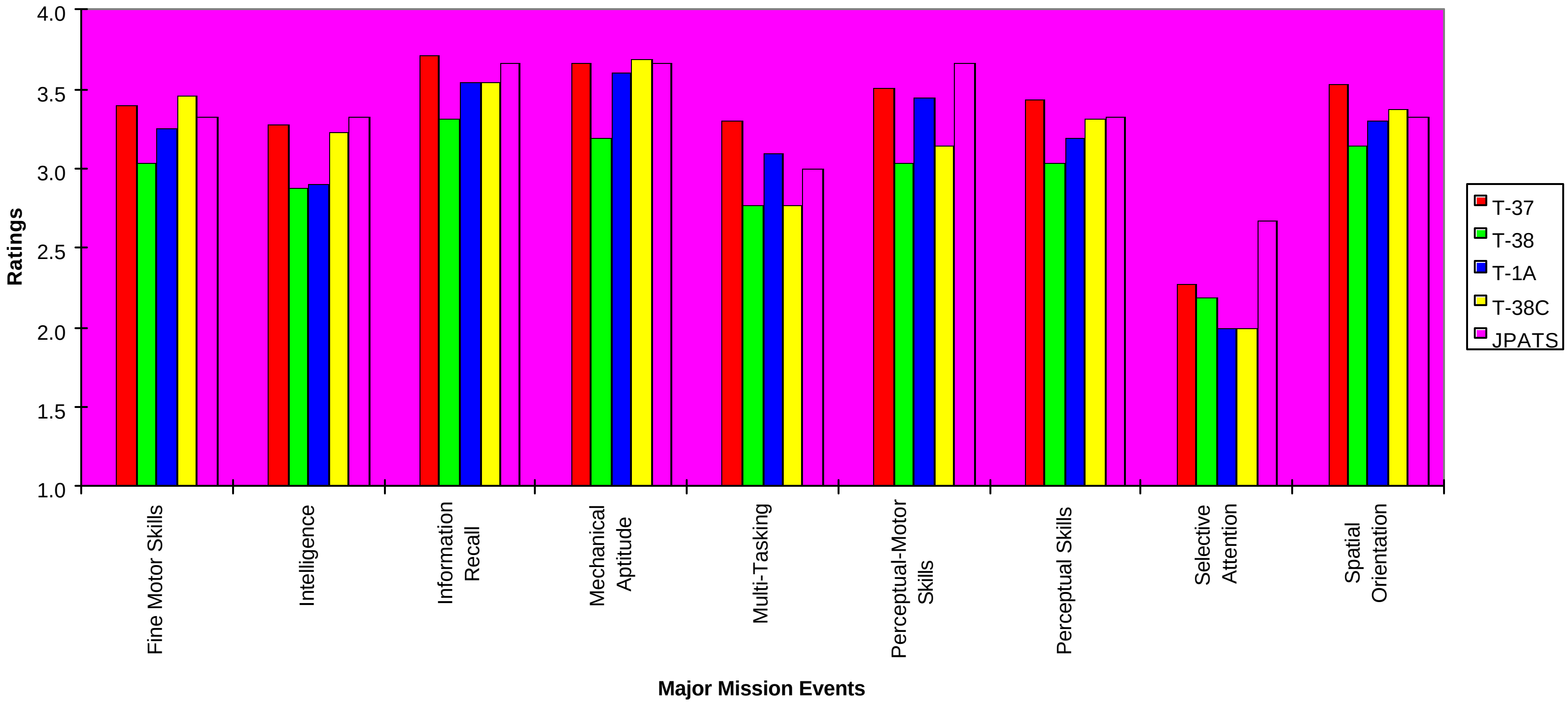
Appendix A-11. Importance - No Students



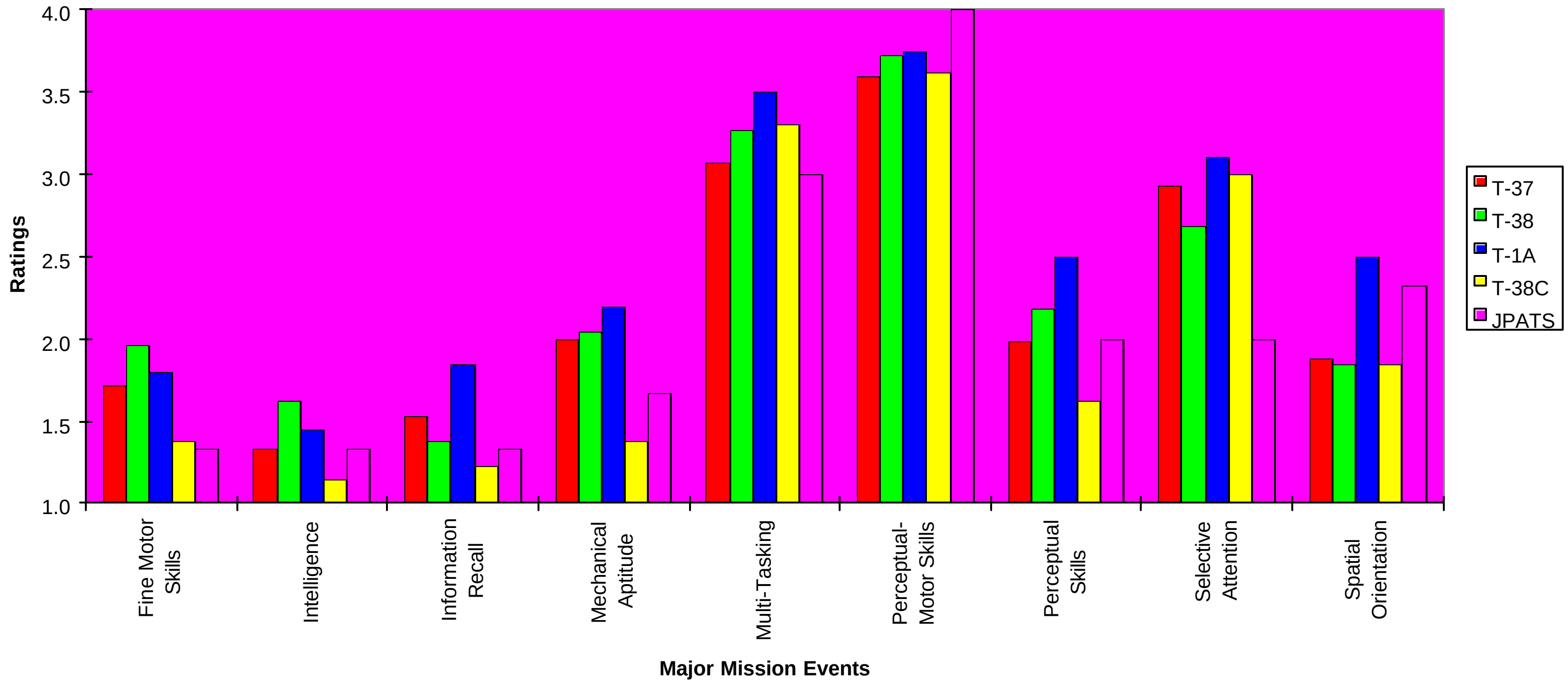
Appendix A-12. Difficulty - No Students



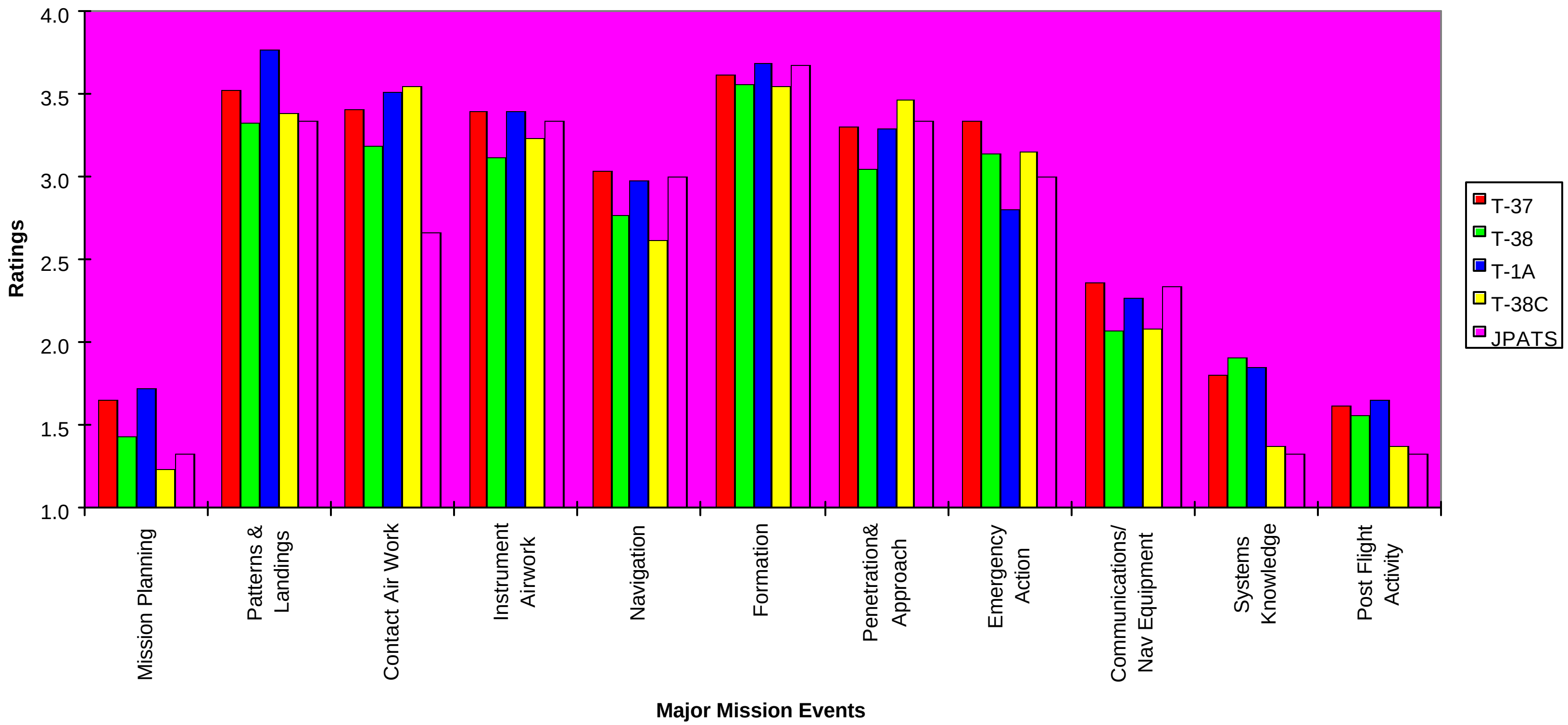
Appendix A-13. Penetration and Approach - No Students



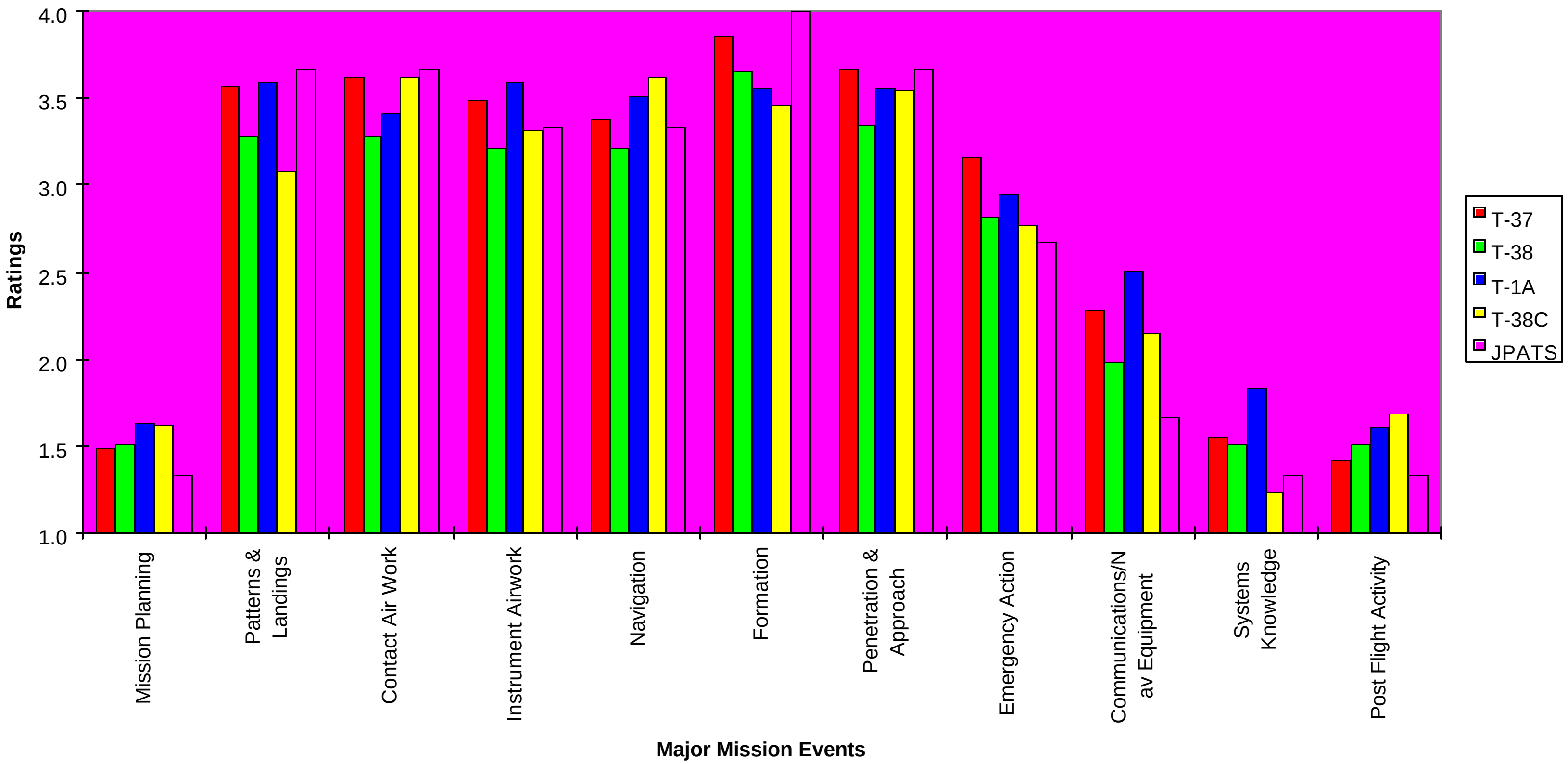
Appendix A-14. Systems Knowledge



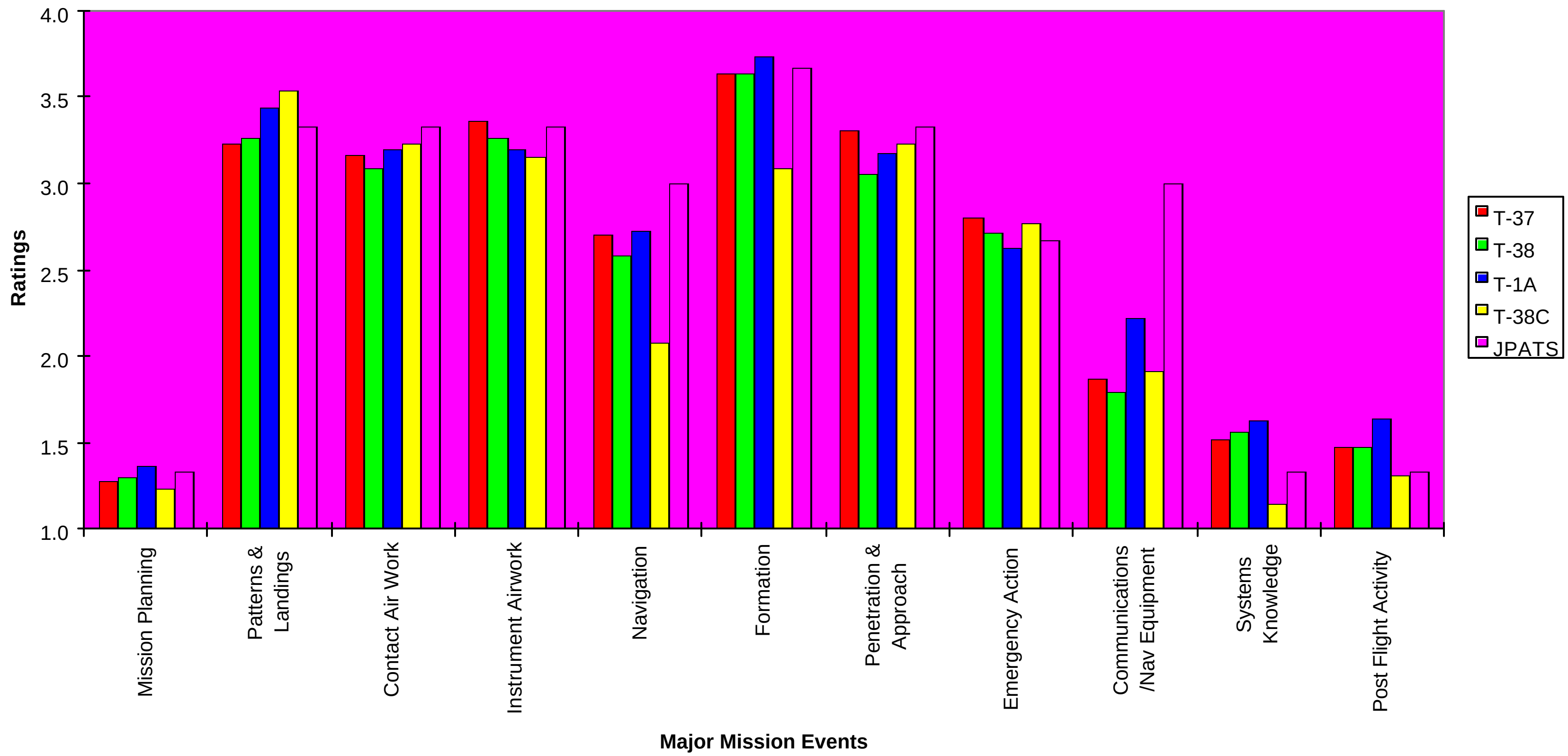
Appendix A-15. Fine Motor Skills



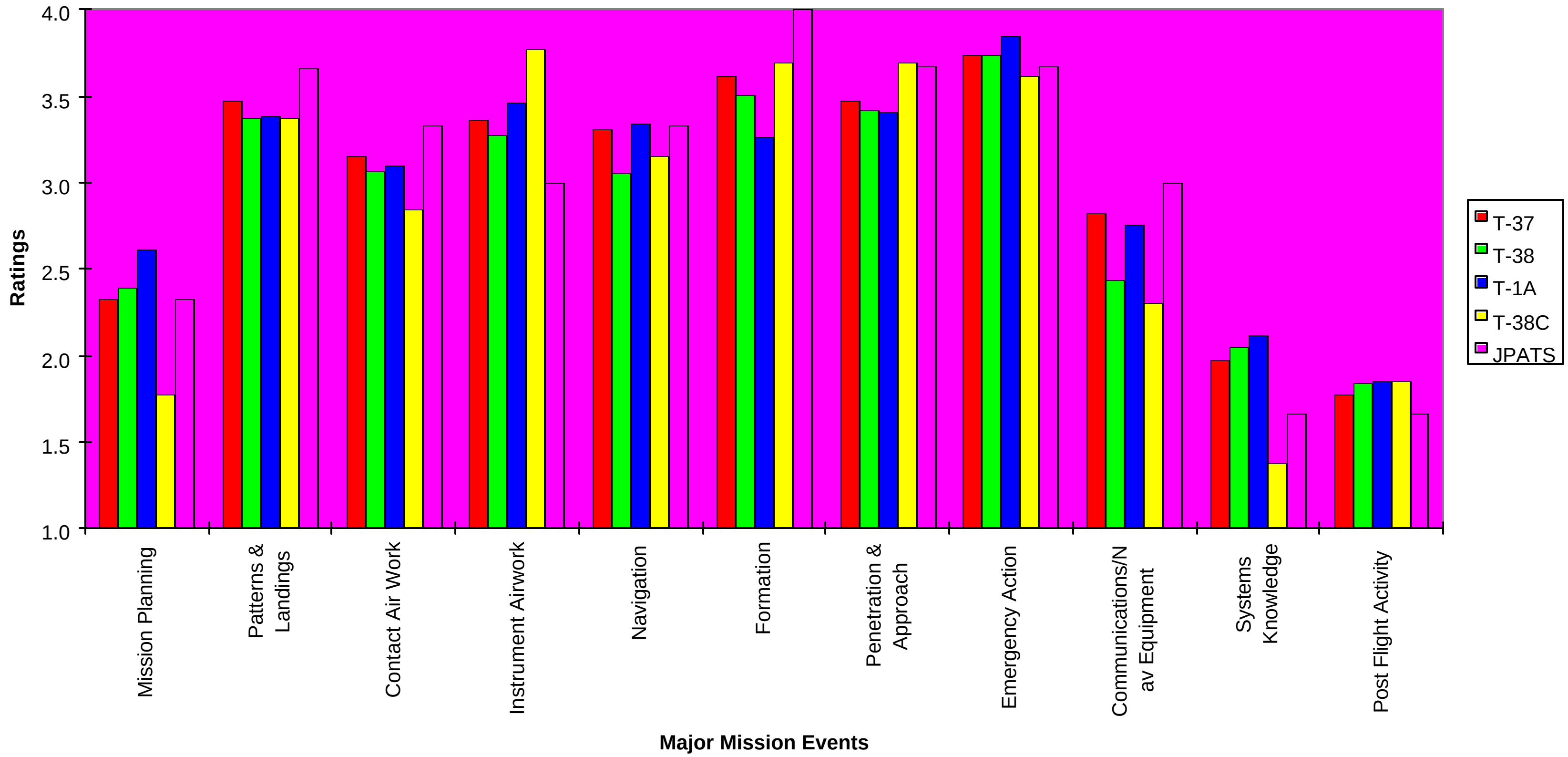
Appendix A-16. Information Recall



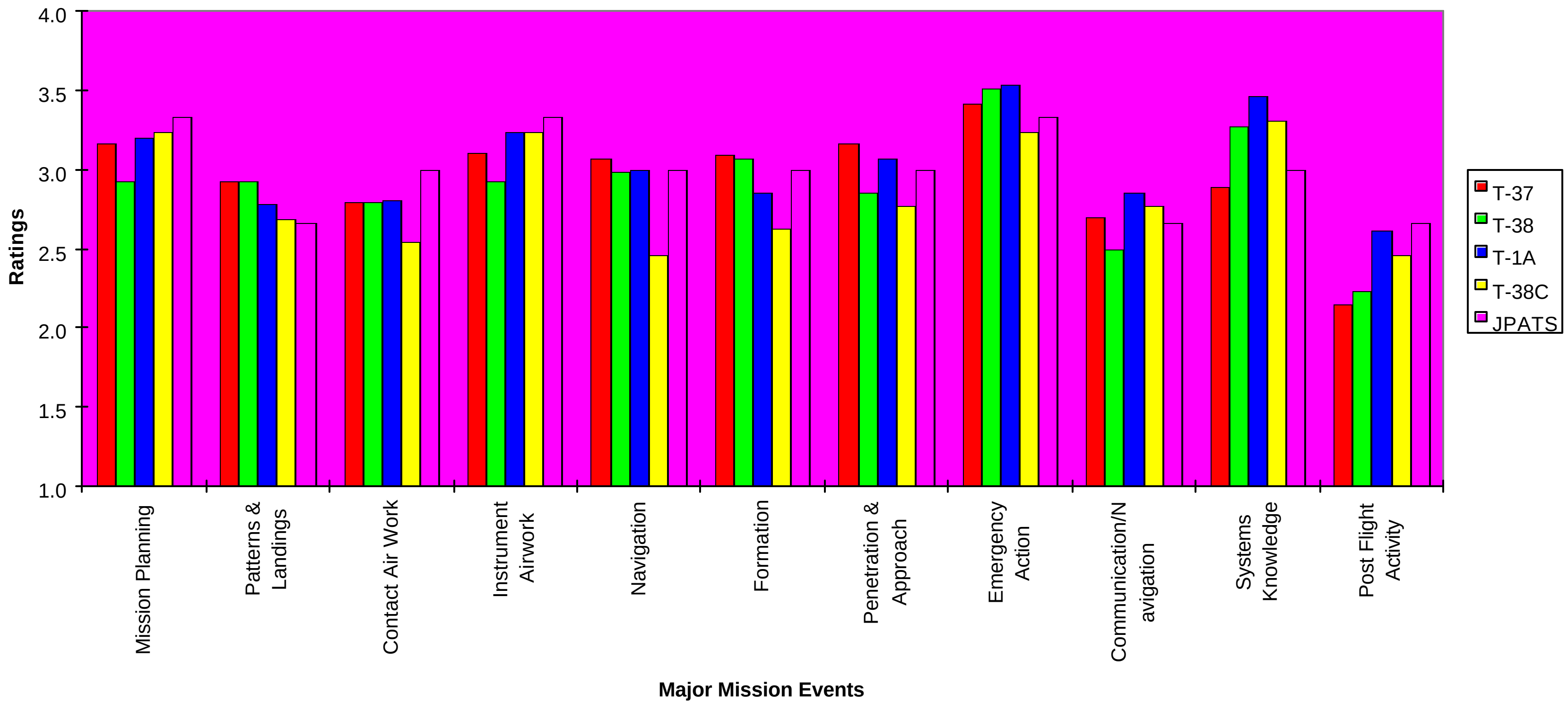
Appendix A-17. Intelligence



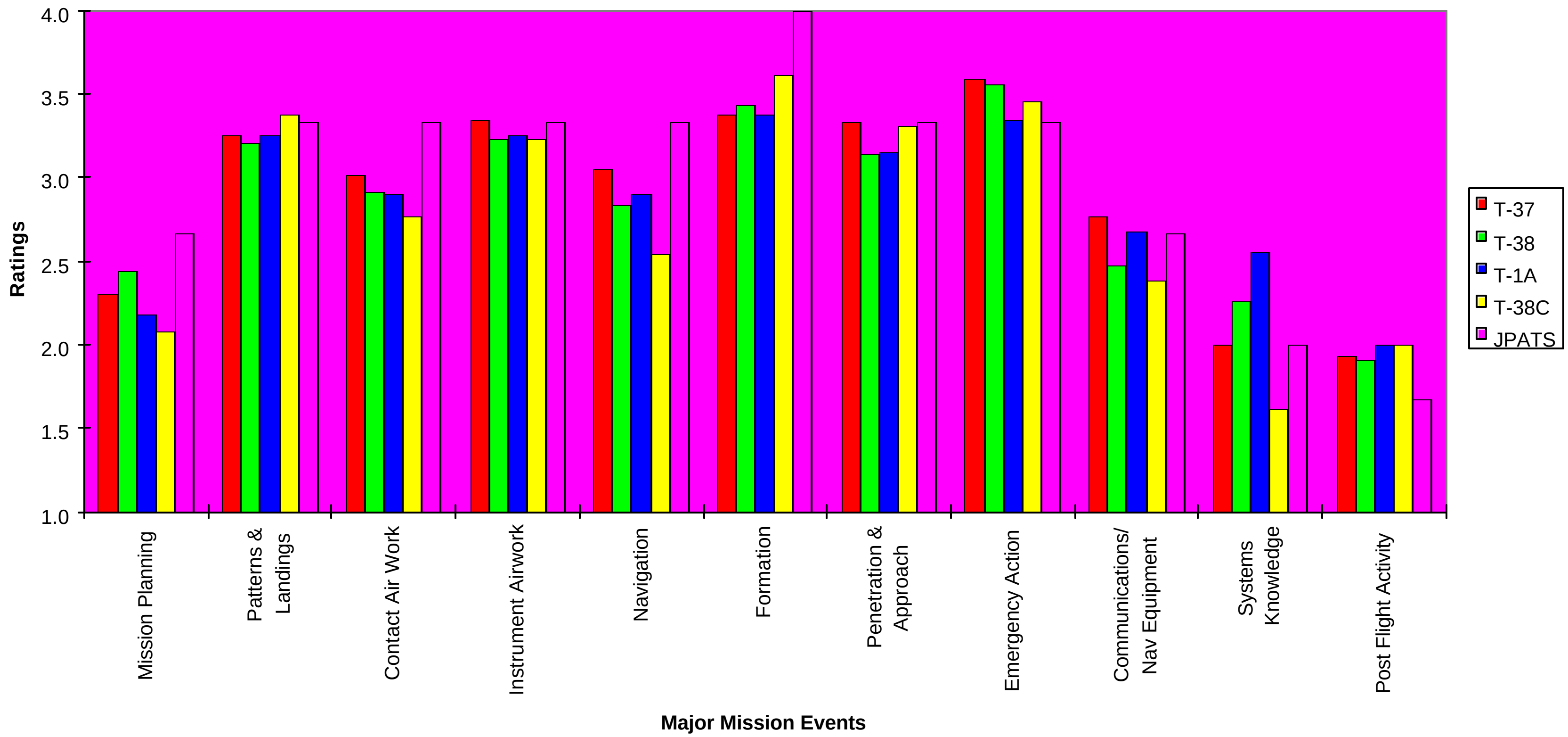
Appendix A-18. Mechanical Aptitude



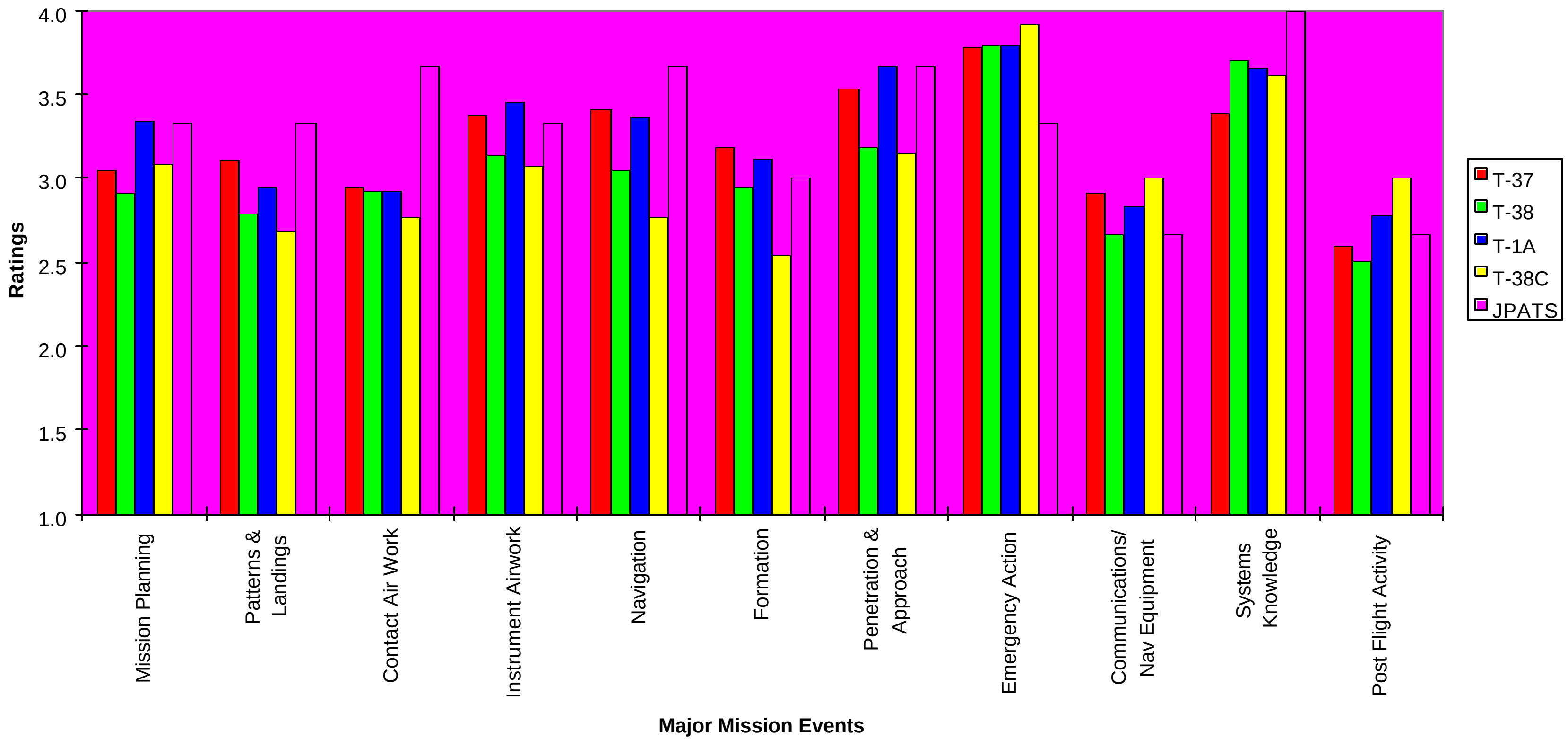
Appendix A-19. Multi-Tasking



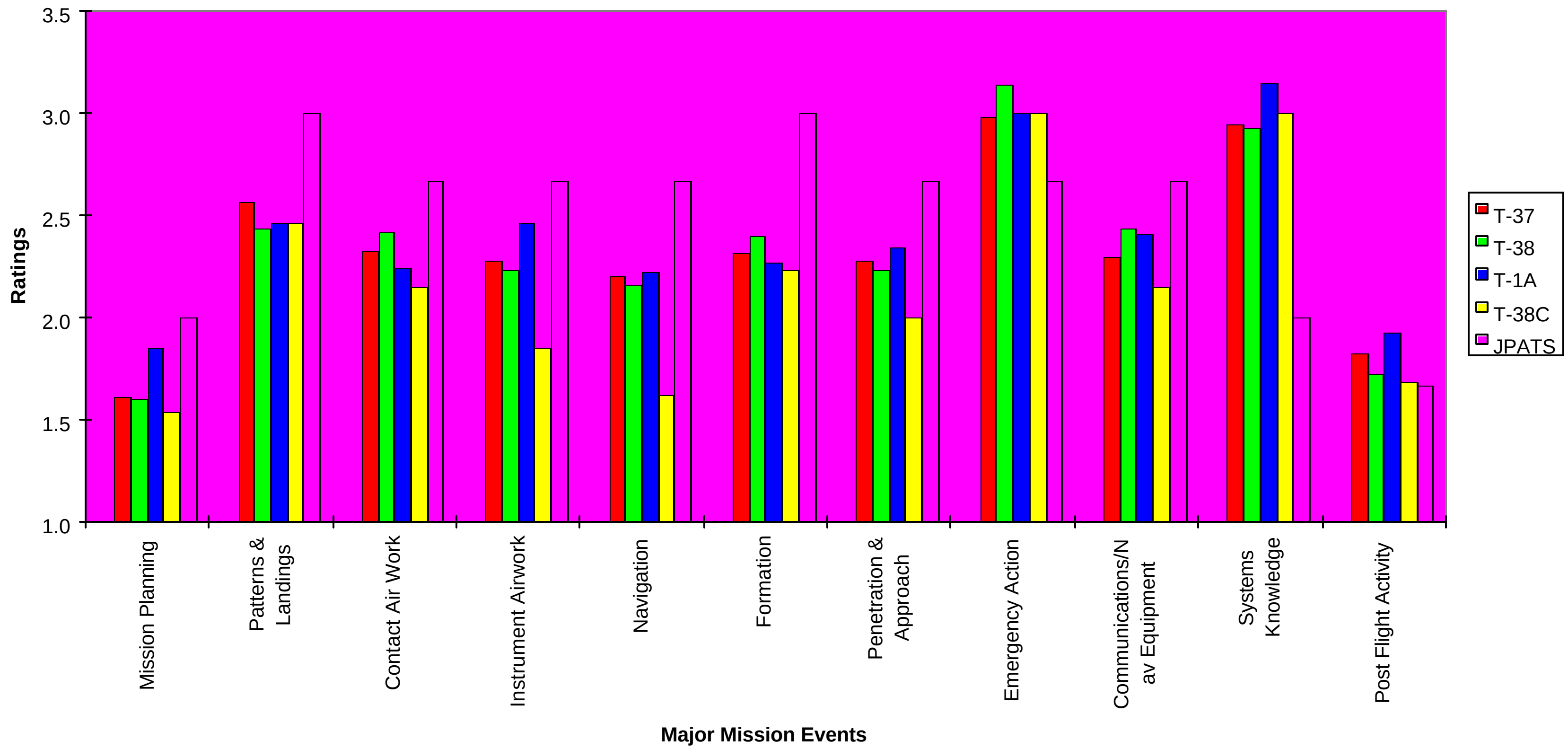
Appendix A-20. Perceptual Skills



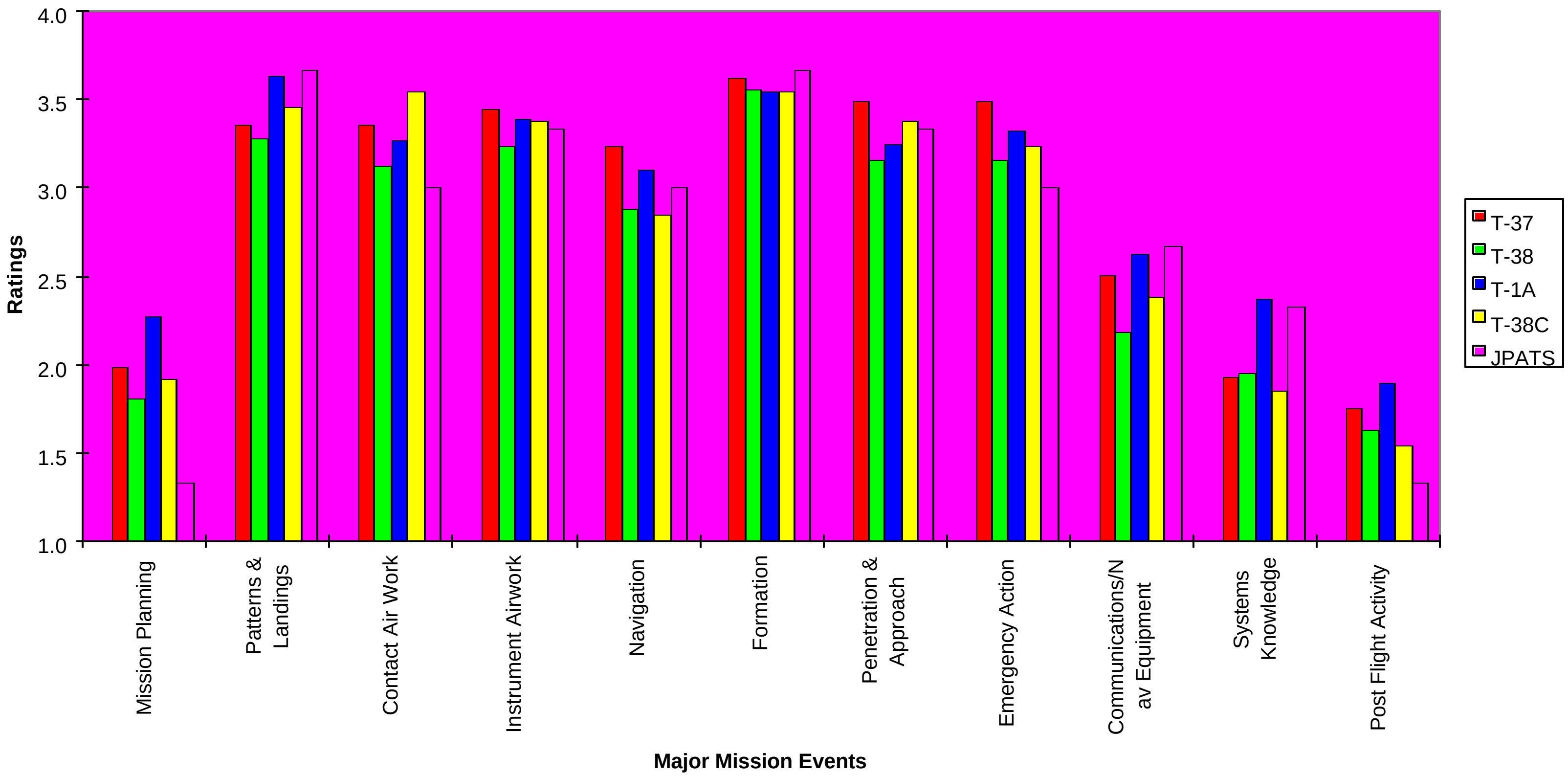
Appendix A-21. Perceptual Motor Skills



Appendix A-22. Selective Attention



Appendix A-23. Spatial Orientation



APPENDIX B

B-1. Importance

Importance	Mission Planning	Patterns & Landings	Contact Airwork	Instrument Airwork	Navigation	Formation	Penetration and Approach	Emergency Action	Communications and Nav Equipment	Systems Knowledge	Post Flight Activity	Row Averag
-37	4.52	4.87	4.13	4.38	4.52	3.64	4.62	4.95	4.30	4.54	3.46	4.36
-38	4.47	4.81	4.07	4.40	4.23	4.63	4.30	4.81	4.05	4.60	3.51	4.35
-1A	4.73	4.76	3.83	4.56	4.56	3.54	4.59	4.80	4.27	4.56	3.58	4.34
-38C	4.62	4.85	4.23	4.77	4.46	4.69	4.69	5.00	3.92	4.54	3.69	4.50
PATS	4.33	5.00	4.00	4.67	4.33	4.00	4.33	5.00	3.67	4.67	3.33	4.30
olumn Average	4.53	4.86	4.05	4.56	4.42	4.10	4.51	4.91	4.04	4.58	3.51	

B-2. Difficulty

ifficulty	Mission Planning	Patterns & Landings	Contact Airwork	Instrument Airwork	Navigation	Formation	Penetration and Approach	Emergency Action	Communications and Nav Equipment	Systems Knowledge	Post Flight Activity	Row Averag
-37	2.97	3.80	3.48	3.63	3.45	3.73	3.77	3.78	3.07	3.03	2.25	3.36
-38	3.02	3.83	3.24	3.40	3.17	4.10	3.40	3.79	2.64	3.27	2.31	3.29
-1A	3.29	3.90	3.05	3.71	3.20	3.83	3.63	3.87	3.02	3.61	2.38	3.41
-38C	2.77	3.46	3.31	3.69	2.92	3.85	3.46	3.15	2.69	2.95	2.15	3.13
PATS	3.33	4.67	4.00	4.00	3.67	4.33	4.00	4.00	3.00	3.33	2.33	3.70
olumn Average	3.08	3.93	3.42	3.69	3.28	3.97	3.65	3.72	2.88	3.24	2.28	

B-3. Mission Planning

ission Planning	Fine Motor Skills	Intelligence	Information Recall	Mechanical Aptitude	Multi-Tasking	Perceptual Motor Skills	Perceptual Skills	Selective Attention	Spatial Orientation	Row Average
-37	1.66	1.28	1.49	2.33	3.16	3.05	2.30	1.61	1.98	2.10
-38	1.43	1.31	1.52	2.40	2.95	2.90	2.43	1.62	1.81	2.04
-1A	1.75	1.38	1.63	2.63	3.20	2.18	2.30	1.88	2.28	2.14
-38C	1.23	1.23	1.62	1.77	3.23	3.08	2.08	1.54	1.92	1.97
PATS	1.33	1.33	1.33	2.33	3.33	3.33	2.67	2.00	1.33	2.11
olumn Average	1.48	1.31	1.52	2.29	3.17	2.91	2.36	1.73	1.86	

B-4. Patterns and Landings

atterns & Landings	Fine Motor Skills	Intelligence	Information Recall	Mechanical Aptitude	Multi-Tasking	Perceptual Motor Skills	Perceptual Skills	Selective Attention	Spatial Orientation	Row Average
-37	3.52	3.23	3.57	3.48	2.93	3.11	3.25	3.57	3.36	3.34
-38	3.33	3.26	3.27	3.37	2.93	2.79	3.21	2.44	3.28	3.10
-1A	3.75	3.43	3.60	3.40	2.78	2.95	3.25	2.48	3.65	3.25
-38C	3.38	3.54	3.07	3.38	2.69	2.69	3.38	2.46	3.46	3.12
PATS	3.33	3.33	3.67	3.67	2.67	3.33	3.33	3.00	3.67	3.33
olumn Average	3.46	3.36	3.44	3.46	2.80	2.97	3.28	2.79	3.48	

B-5. Contact Airwork

ontact Airwork	Fine Motor Skills	Intelligence	Information Recall	Mechanical Aptitude	Multi-Tasking	Perceptual Motor Skills	Perceptual Skills	Selective Attention	Spatial Orientation	Row Average

-37	3.40	3.15	3.62	3.15	2.78	2.95	3.02	2.33	3.35	3.08
-38	3.19	3.10	3.29	3.07	2.81	2.93	2.90	2.40	3.12	2.98
-1A	3.53	3.18	3.43	3.13	2.83	2.93	2.90	2.28	3.28	3.05
-38C	3.50	3.17	3.67	2.83	2.58	2.83	2.75	2.08	3.58	3.00
PATS	2.67	3.33	3.67	3.33	3.00	3.67	3.33	2.67	3.00	3.19
olumn Average	3.26	3.19	3.54	3.10	2.80	3.06	2.98	2.35	3.27	

B-6. Instrument Airwork

nstrument Airwork	Fine Motor Skills	Intelligence	Information Recall	Mechanical Aptitude	Multi-Tasking	Perceptual Motor Skills	Perceptual Skills	Selective Attention	Spatial Orientation	Row Average
-37	3.38	3.35	3.48	3.35	3.08	3.37	3.33	2.28	3.43	3.23
-38	3.12	3.29	3.24	3.29	2.95	3.14	3.24	2.24	3.26	3.09
-1A	3.40	3.20	3.60	3.50	3.25	3.48	3.25	2.50	3.40	3.29
-38C	3.23	3.15	3.31	3.77	3.23	3.08	3.23	1.85	3.38	3.14
PATS	3.33	3.33	3.33	3.00	3.33	3.33	3.33	2.67	3.33	3.22
olumn Average	3.29	3.26	3.39	3.38	3.17	3.28	3.28	2.31	3.36	

B-7. Navigation

Iavigation	Fine Motor Skills	Intelligence	Information Recall	Mechanical Aptitude	Multi-Tasking	Perceptual Motor Skills	Perceptual Skills	Selective Attention	Spatial Orientation	Row Average
-37	3.03	2.70	3.38	3.30	3.05	3.40	3.03	2.20	3.23	3.04

-38	2.76	2.60	3.24	3.05	3.00	3.05	2.83	2.17	2.90	2.84
-1A	2.98	2.75	3.53	3.38	3.03	3.38	2.90	2.25	3.13	3.04
-38C	2.62	2.08	3.62	3.15	2.46	2.77	2.54	1.62	2.84	2.63
PATS	3.00	3.00	3.33	3.33	3.00	3.67	3.33	2.67	3.00	3.15
olumn Average	2.88	2.63	3.42	3.24	2.91	3.25	2.93	2.18	3.02	

B-8. Formation

ormation	Fine Motor Skills	Intelligence	Information Recall	Mechanical Aptitude	Multi-Tasking	Perceptual Motor Skills	Perceptual Skills	Selective Attention	Spatial Orientation	Row Average
-37	3.67	3.67	3.84	3.65	3.08	3.20	3.39	2.29	3.65	3.38
-38	3.54	3.63	3.66	3.49	3.10	2.98	3.44	2.37	3.54	3.31
-1A	3.70	3.75	3.58	3.30	2.88	3.15	3.38	2.28	3.55	3.29
-38C	3.54	3.69	3.46	3.69	2.62	2.54	3.62	2.23	3.54	3.21
PATS	3.67	3.67	4.00	4.00	3.00	3.00	4.00	3.00	3.67	3.56
	3.62	3.68	3.71	3.63	2.94	2.97	3.57	2.43	3.59	

B-9. Penetration and Approach

enetration & pproach	Fine Motor Skills	Intelligence	Information Recall	Mechanical Aptitude	Multi-Tasking	Perceptual Motor Skills	Perceptual Skills	Selective Attention	Spatial Orientation	Row Average
-37	3.28	3.30	3.67	3.47	3.15	3.53	3.32	2.28	3.50	3.28
-38	3.05	3.05	3.36	3.43	2.88	3.19	3.14	2.24	3.17	3.06
-1A	3.31	3.15	3.56	3.44	3.05	3.36	3.13	2.67	3.23	3.21

T-38C	3.46	3.23	3.54	3.69	2.77	3.15	3.31	2.00	3.38	3.17
PATS	3.33	3.33	3.67	3.67	3.00	3.67	3.33	2.67	3.33	3.33
Column Average	3.29	3.21	3.56	3.54	2.97	3.38	3.25	2.37	3.32	

B-10. Emergency Action

Emergency Action	Fine Motor Skills	Intelligence	Information Recall	Mechanical Aptitude	Multi-Tasking	Perceptual Motor Skills	Perceptual Skills	Selective Attention	Spatial Orientation	Row Average
T-37	3.35	2.80	3.18	3.73	3.40	3.78	3.58	2.97	3.50	3.37
T-38	3.14	2.74	2.83	3.74	3.53	3.79	3.55	3.17	3.19	3.30
T-1A	2.83	2.65	2.98	3.85	3.53	3.80	3.35	3.00	3.30	3.25
T-38C	3.15	2.77	2.77	3.62	3.23	3.92	3.46	3.00	3.23	3.24
PATS	3.00	2.37	2.37	3.67	3.33	3.33	3.33	2.67	3.00	3.01
Column Average	3.09	2.67	2.83	3.72	3.40	3.72	3.45	2.96	3.24	

B-11. Communications and Navigation Equipment

Communications & Nav Equipment	Fine Motor Skills	Intelligence	Information Recall	Mechanical Aptitude	Multi-Tasking	Perceptual Motor Skills	Perceptual Skills	Selective Attention	Spatial Orientation	Row Average
T-37	2.37	1.86	2.28	2.82	2.70	2.92	2.77	2.30	2.52	2.50
T-38	2.07	1.80	2.00	2.41	2.46	2.66	2.44	2.44	2.20	2.28
T-1A	2.30	2.25	2.52	2.78	2.85	2.83	2.68	2.43	2.65	2.59
T-38C	2.00	1.83	2.08	2.25	2.75	3.00	2.33	2.08	2.33	2.29
PATS	2.33	3.00	1.67	3.00	2.67	2.67	2.67	2.67	2.67	2.59

olumn Average	2.21	2.15	2.11	2.65	2.69	2.82	2.58	2.38	2.47	

B-12. Systems Knowledge

ystems Knowledge	Fine Motor Skills	Intelligence	Information Recall	Mechanical Aptitude	Multi-Tasking	Perceptual Motor Skills	Perceptual Skills	Selective Attention	Spatial Orientation	Row Average
-37	1.80	1.53	1.57	1.93	2.90	3.38	1.98	2.93	1.95	2.22
-38	1.85	1.56	1.54	2.04	3.27	3.68	2.24	2.93	1.98	2.34
-1A	1.88	1.65	1.85	2.13	3.48	3.65	2.55	3.18	2.35	2.52
-38C	1.38	1.15	1.23	1.38	3.31	3.62	1.62	3.00	1.85	2.06
PATS	1.33	1.33	1.33	1.67	3.00	4.00	2.00	2.00	2.33	2.11
olumn Average	1.65	1.44	1.50	1.83	3.19	3.67	2.08	2.81	2.09	

B-13. Post Flight Activity

ost Flight Activity	Fine Motor Skills	Intelligence	Information Recall	Mechanical Aptitude	Multi-Tasking	Perceptual Motor Skills	Perceptual Skills	Selective Attention	Spatial Orientation	Row Average
-37	1.61	1.47	1.42	1.76	2.15	2.58	1.93	1.81	1.76	1.83
-38	1.55	1.48	1.48	1.83	2.21	2.48	1.90	1.71	1.64	1.81
-1A	1.69	1.64	1.64	1.87	2.59	2.82	1.97	1.92	1.90	2.00
-38C	1.38	1.31	1.69	1.85	2.46	3.00	2.00	1.69	1.54	1.88
PATS	1.33	1.33	1.33	1.67	2.67	2.67	1.67	1.67	1.33	1.74
olumn Average	1.51	1.45	1.51	1.80	2.42	2.71	1.89	1.76	1.63	

B-14. Importance - Students

~~I~~mportance - Students	Mission Planning	Patterns & Landings	Contact Air Work	Instrument Airwork	Navigation	Formation	Penetration & Approach	Emergency Action	Communications & Nav Equipment	Systems Knowledge	Post Flight Activity	Row Averag
-37	4.59	4.83	4.07	4.40	4.57	4.10	4.69	4.95	4.24	4.52	3.52	4.41
-38	4.57	4.73	4.11	4.35	4.27	4.54	4.27	4.77	3.88	4.54	3.35	4.31
-1A	4.76	4.67	3.10	4.38	4.43	3.38	4.57	4.71	4.10	4.38	3.33	4.16
-38C	4.62	4.85	4.23	4.77	4.46	4.69	4.69	5.00	3.92	4.54	3.69	4.50
PATS	4.33	5.00	4.00	4.67	4.33	4.00	4.33	5.00	3.67	4.67	3.33	4.30
olumn Average	4.57	4.82	3.90	4.51	4.41	4.14	4.51	4.89	3.96	4.53	3.44	

B-15. Difficulty - Students

ifficulty - Students	Mission Planning	Patterns & Landings	Contact Air Work	Instrument Airwork	Navigation	Formation	Penetration & Approach	Emergency Action	Communications & Nav Equipment	Systems Knowledge	Post Flight Activity	Row Averag
-37	3.14	3.93	3.59	3.78	3.66	4.22	4.00	3.88	3.12	3.20	2.32	3.53
-38	3.00	3.88	3.29	3.38	3.08	4.29	3.25	3.83	2.58	3.21	2.25	3.28
-1A	3.29	4.00	3.10	3.67	3.19	3.81	3.67	3.95	3.05	3.71	2.43	3.44
-38C	2.83	3.50	3.33	3.75	2.92	3.83	3.42	3.17	2.67	2.83	2.17	3.13
PATS	3.33	4.67	4.00	4.00	3.67	4.33	4.00	4.00	3.00	3.33	2.33	3.70
olumn Average	3.12	4.00	3.46	3.72	3.30	4.10	3.67	3.77	2.88	3.26	2.30	

B-16. Penetration and Approach - Students

Penetration & Approach - Students	Fine Motor Skills	Intelligence	Information Recall	Mechanical Aptitude	Multi-Tasking	Perceptual Motor Skills	Perceptual Skills	Selective Attention	Spatial Orientation	Row Average
T-37	3.40	3.28	3.72	3.67	3.30	3.51	3.44	2.28	3.53	3.35
T-38	3.04	2.88	3.31	3.19	2.77	3.04	3.04	2.19	3.15	2.96
T-1A	3.25	2.90	3.55	3.60	3.10	3.45	3.20	2.00	3.30	3.15
T-38C	3.46	3.23	3.54	3.69	2.77	3.15	3.31	2.00	3.38	3.17
PATS	3.33	3.33	3.67	3.67	3.00	3.67	3.33	2.67	3.33	3.33
Column Average	3.30	3.12	3.56	3.56	2.99	3.36	3.26	2.23	3.34	

B-17. Systems Knowledge - Students

Systems Knowledge - Students	Fine Motor Skills	Intelligence	Information Recall	Mechanical Aptitude	Multi-Tasking	Perceptual Motor Skills	Perceptual Skills	Selective Attention	Spatial Orientation	Row Average
T-37	1.72	1.33	1.53	2.00	3.07	3.60	1.98	2.93	1.88	2.23
T-38	1.96	1.62	1.38	2.04	3.27	3.73	2.19	2.69	1.85	2.30
T-1A	1.80	1.45	1.85	2.20	3.50	3.75	2.50	3.10	2.50	2.52
T-38C	1.38	1.15	1.23	1.38	3.31	3.62	1.62	3.00	1.85	2.06
PATS	1.33	1.33	1.33	1.67	3.00	4.00	2.00	2.00	2.33	2.11
Column Average	1.64	1.38	1.46	1.86	3.23	3.74	2.06	2.74	2.08	

B-18. Fine Motor Skills

Fine Motor Skills	Mission Planning	Patterns & Landings	Contact Air Work	Instrument Airwork	Navigation	Formation	Penetration & Approach	Emergency Action	Communications & Nav Equipment	Systems Knowledge	Post Flight Activity	Row Average
T-37	1.66	3.52	3.41	3.39	3.03	3.62	3.30	3.34	2.36	1.80	1.62	2.82
T-38	1.43	3.33	3.19	3.12	2.77	3.56	3.05	3.14	2.07	1.91	1.56	2.65
T-1A	1.72	3.76	3.51	3.39	2.98	3.68	3.29	2.80	2.27	1.85	1.66	2.81
T-38C	1.23	3.38	3.54	3.23	2.62	3.54	3.46	3.15	2.08	1.38	1.38	2.64
JPATS	1.33	3.33	2.67	3.33	3.00	3.67	3.33	3.00	2.33	1.33	1.33	2.60
Column Average	1.47	3.46	3.26	3.29	2.88	3.61	3.29	3.09	2.22	1.65	1.51	

B-19. Information Recall

Information Recall	Mission Planning	Patterns & Landings	Contact Air Work	Instrument Airwork	Navigation	Formation	Penetration & Approach	Emergency Action	Communications & Nav Equipment	Systems Knowledge	Post Flight Activity	Row Average
T-37	1.49	3.57	3.62	3.49	3.38	3.85	3.67	3.16	2.28	1.56	1.42	2.86
T-38	1.51	3.28	3.28	3.21	3.21	3.65	3.35	2.81	1.98	1.51	1.51	2.66
T-1A	1.63	3.59	3.41	3.59	3.51	3.56	3.56	2.95	2.51	1.83	1.61	2.89
T-38C	1.62	3.08	3.62	3.31	3.62	3.46	3.54	2.77	2.15	1.23	1.69	2.74
JPATS	1.33	3.67	3.67	3.33	3.33	4.00	3.67	2.67	1.67	1.33	1.33	2.73
Column Average	1.52	3.44	3.52	3.39	3.41	3.70	3.56	2.87	2.12	1.49	1.51	

B-20. Intelligence

ntelligence	Mission Planning	Patterns & Landings	Contact Air Work	Instrument Airwork	Navigation	Formation	Penetration & Approach	Emergency Action	Communications & Nav Equipment	Systems Knowledge	Post Flight Activity	Row Averag
-37	1.28	3.23	3.16	3.36	2.70	3.64	3.31	2.80	1.87	1.52	1.47	2.58
-38	1.30	3.26	3.09	3.26	2.58	3.64	3.05	2.72	1.79	1.56	1.47	2.52
-1A	1.37	3.44	3.20	3.20	2.73	3.73	3.17	2.63	2.22	1.63	1.64	2.63
-38C	1.23	3.54	3.23	3.15	2.08	3.09	3.23	2.77	1.92	1.15	1.31	2.43
PATS	1.33	3.33	3.33	3.33	3.00	3.67	3.33	2.67	3.00	1.33	1.33	2.70
olumn Average	1.30	3.36	3.20	3.26	2.62	3.55	3.22	2.72	2.16	1.44	1.44	

B-21. Mechanical Aptitude

echanical Aptitude	Mission Planning	Patterns & Landings	Contact Air Work	Instrument Airwork	Navigation	Formation	Penetration & Approach	Emergency Action	Communications & Nav Equipment	Systems Knowledge	Post Flight Activity	Row Averag
-37	2.33	3.48	3.15	3.36	3.31	3.62	3.48	3.74	2.82	1.97	1.78	3.00
-38	2.39	3.37	3.07	3.28	3.05	3.51	3.42	3.74	2.44	2.05	1.84	2.92
-1A	2.61	3.39	3.10	3.46	3.34	3.27	3.41	3.85	2.76	2.12	1.85	3.01
-38C	1.77	3.38	2.85	3.77	3.15	3.69	3.69	3.62	2.31	1.38	1.85	2.86
PATS	2.33	3.67	3.33	3.00	3.33	4.00	3.67	3.67	3.00	1.67	1.67	3.03
olumn Average	2.29	3.46	3.10	3.37	3.24	3.62	3.53	3.72	2.67	1.84	1.80	

B-22. Multi-Tasking

ulti-Tasking	Mission Planning	Patterns & Landings	Contact Air Work	Instrument Airwork	Navigation	Formation	Penetration & Approach	Emergency Action	Communications & Nav Equipment	Systems Knowledge	Post Flight Activity	Row Averag

-37	3.16	2.93	2.79	3.10	3.07	3.09	3.16	3.41	2.70	2.89	2.15	2.95
-38	2.93	2.93	2.79	2.93	2.98	3.07	2.86	3.51	2.49	3.27	2.23	2.91
-1A	3.20	2.78	2.80	3.24	3.00	2.85	3.07	3.54	2.85	3.46	2.61	3.04
-38C	3.23	2.69	2.54	3.23	2.46	2.62	2.77	3.23	2.77	3.31	2.46	2.85
PATS	3.33	2.67	3.00	3.33	3.00	3.00	3.00	3.33	2.67	3.00	2.67	3.00
olumn Average	3.17	2.80	2.78	3.17	2.90	2.93	2.97	3.40	2.70	3.19	2.42	

B-23. Perceptual Skills

erceptual Skills	Mission Planning	Patterns & Landings	Contact Air Work	Instrument Airwork	Navigation	Formation	Penetration & Approach	Emergency Action	Communications & Nav Equipment	Systems Knowledge	Post Flight Activity	Row Averag
-37	2.30	3.25	3.02	3.34	3.05	3.38	3.33	3.59	2.77	2.00	1.93	2.91
-38	2.44	3.21	2.91	3.23	2.84	3.44	3.14	3.56	2.47	2.26	1.91	2.86
-1A	2.18	3.25	2.90	3.25	2.90	3.38	3.15	3.35	2.68	2.55	2.00	2.87
-38C	2.08	3.38	2.77	3.23	2.54	3.62	3.31	3.46	2.38	1.62	2.00	2.76
PATS	2.67	3.33	3.33	3.33	3.33	4.00	3.33	3.33	2.67	2.00	1.67	3.00
olumn Average	2.33	3.28	2.99	3.28	2.93	3.56	3.25	3.46	2.59	2.09	1.90	

B-24. Perceptual Motor Skills

erceptual Motor Skills	Mission Planning	Patterns & Landings	Contact Air Work	Instrument Airwork	Navigation	Formation	Penetration & Approach	Emergency Action	Communications & Nav Equipment	Systems Knowledge	Post Flight Activity	Row Averag
-37	3.05	3.11	2.95	3.38	3.41	3.19	3.54	3.78	2.92	3.39	2.60	3.21
-38	2.91	2.79	2.93	3.14	3.05	2.95	3.19	3.79	2.67	3.70	2.51	3.06

-1A	3.34	2.95	2.93	3.46	3.37	3.12	3.67	3.80	2.83	3.66	2.78	3.26
-38C	3.08	2.69	2.77	3.07	2.77	2.54	3.15	3.92	3.00	3.62	3.00	3.06
PATS	3.33	3.33	3.67	3.33	3.67	3.00	3.67	3.33	2.67	4.00	2.67	3.33
olumn Average	3.14	2.97	3.05	3.28	3.25	2.96	3.44	3.72	2.82	3.67	2.71	

B-25. Selective Attention

elective Attention	Mission Planning	Patterns & Landings	Contact Air Work	Instrument Airwork	Navigation	Formation	Penetration & Approach	Emergency Action	Communications & Nav Equipment	Systems Knowledge	Post Flight Activity	Row Averag
-37	1.61	2.57	2.33	2.28	2.20	2.32	2.28	2.98	2.30	2.95	1.82	2.33
-38	1.60	2.44	2.42	2.23	2.16	2.40	2.23	3.14	2.44	2.93	1.72	2.34
-1A	1.85	2.46	2.24	2.46	2.22	2.27	2.34	3.00	2.41	3.15	1.93	2.39
-38C	1.54	2.46	2.15	1.85	1.62	2.23	2.00	3.00	2.15	3.00	1.69	2.15
PATS	2.00	3.00	2.67	2.67	2.67	3.00	2.67	2.67	2.67	2.00	1.67	2.52
olumn Average	1.72	2.59	2.36	2.30	2.17	2.44	2.30	2.96	2.39	2.81	1.77	

B-26. Spatial Orientation

patial Orientation	Mission Planning	Patterns & Landings	Contact Air Work	Instrument Airwork	Navigation	Formation	Penetration & Approach	Emergency Action	Communications & Nav Equipment	Systems Knowledge	Post Flight Activity	Row Averag
-37	1.98	3.36	3.36	3.44	3.23	3.62	3.49	3.49	2.51	1.93	1.75	2.92
-38	1.81	3.28	3.12	3.23	2.88	3.56	3.16	3.16	2.19	1.95	1.63	2.72
-1A	2.27	3.63	3.27	3.39	3.10	3.54	3.24	3.32	2.63	2.37	1.90	2.97
-38C	1.92	3.46	3.54	3.38	2.85	3.54	3.38	3.23	2.38	1.85	1.54	2.82

PATS	1.33	3.67	3.00	3.33	3.00	3.67	3.33	3.00	2.67	2.33	1.33	2.79
Column Average	1.86	3.48	3.26	3.35	3.01	3.59	3.32	3.24	2.48	2.09	1.63	